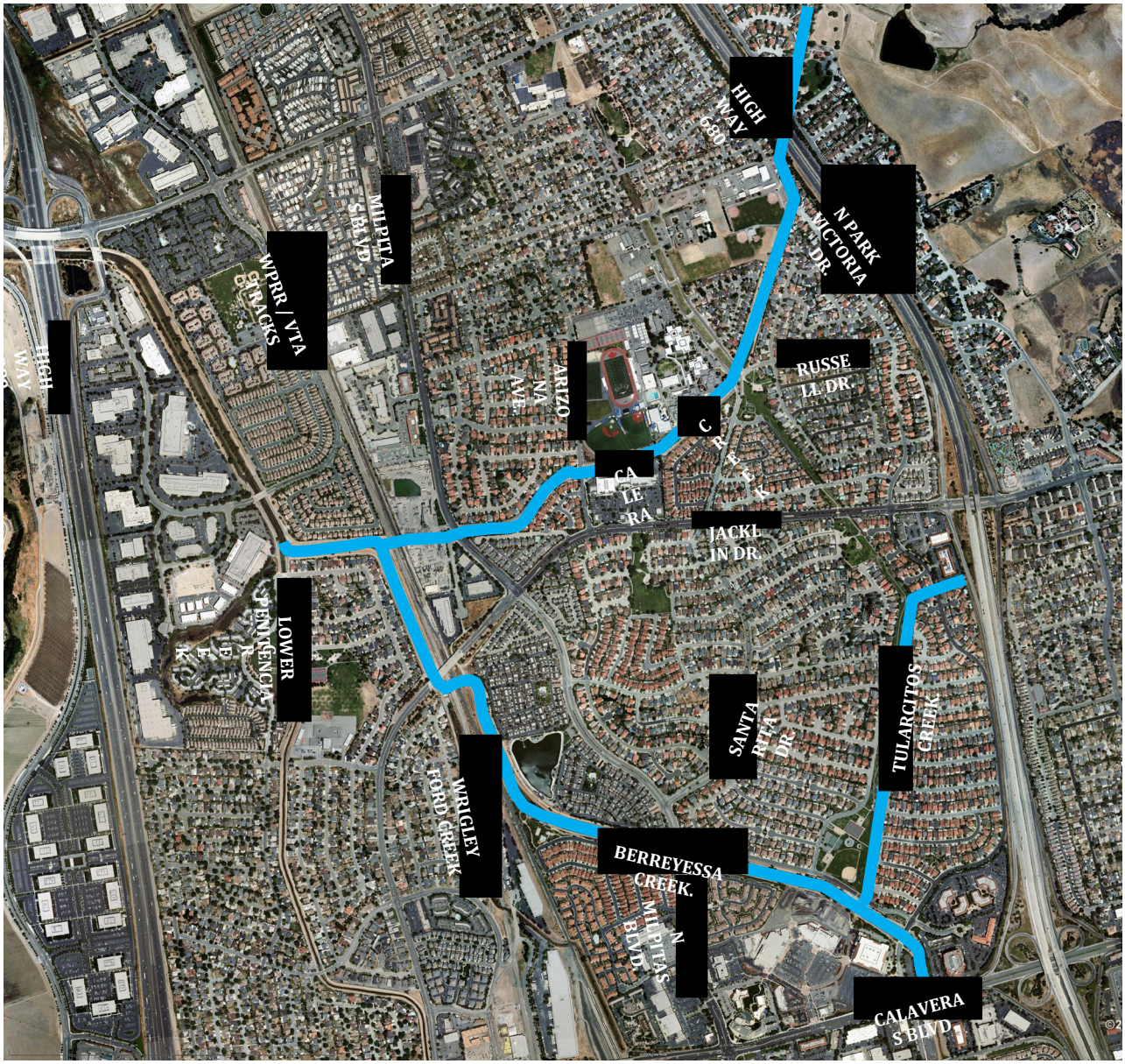
LOWER BERRYESSA CREEK PROJECT
PLANNING STUDY REPORT

MARCH 2010



Santa Clara Valley Water District SM

WINZLER & KELLY

LOWER BERRYESSA CREEK PROJECT

PLANNING STUDY REPORT

PROJECT NO. 40174004

Prepared by Winzler & Kelly

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SANTA CLARA VALLEY WATER DISTRICT

LOWER BERRYESSA CREEK PROJECT

PLANNING STUDY REPORT

PROJECT NO. 40174004

Prepared by Winzler & Kelly

Stephen J. Cox, P.E.
Richard K. Jorgensen, P.E.

This Planning Study Report has been prepared under the direction of the undersigned, who hereby certifies that he is a registered engineer in the State of California.



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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Introduction

The Lower Berryessa Creek Project (Project) is located in the City of Milpitas. The extent of the proposed Project begins at Calaveras Boulevard and continues downstream for approximately 8,700 feet, to the confluence with Lower Penitencia Creek. The Project also includes two tributary creeks, Tularcitos Creek and Calera Creek. The U.S. Army Corps of Engineers and the Santa Clara Valley Water District (District) are currently developing design documents for channel improvements on Upper Berryessa Creek upstream of Calaveras Boulevard.

Flooding has occurred along Berryessa Creek in 1982, 1983 and 1997. Federal Emergency Management Agency (FEMA)/District 100-year flood maps indicate flooding along portions of Lower Berryessa Creek and Calera Creek, but not on Tularcitos Creek. No reports of flooding along Calera Creek or Tularcitos Creek have been discovered. Lower Berryessa Creek cannot contain design flows that take into account future upstream channel improvements. Also, the existing levees on both sides of the creek are structurally stable, but are constructed with highly plastic clay that shrinks and swells, causing erosion and cracking along portions of the levees.

Flows in Lower Berryessa Creek have a backwater effect on most of Tularcitos Creek. Based on hydraulic modeling, Tularcitos Creek cannot contain design flows due to both this backwater effect and inadequate channel capacity.

A portion of Calera Creek extending about 3,000 feet upstream of its confluence with Berryessa Creek is also subject to a backwater effect from flows in Lower Berryessa Creek. This portion of Calera Creek cannot contain design flows due to this backwater effect and inadequate channel capacity. Beyond this portion of the creek, the upstream reaches of Calera Creek cannot contain design flows due to inadequate channel capacity.

Inadequate access makes maintenance of Berryessa Creek, Tularcitos Creek and Calera Creek more difficult, costly and time-consuming.

An evaluation will be carried out in compliance with the California Environmental Quality Act (CEQA) and will address the environmental impacts of and mitigation for the recommended project.

Project Objectives

The objectives of the Project are to:

- Provide flood protection for the design flood event
- Improve access for long-term channel maintenance

- Incorporate opportunities to integrate levees with the City of Milpitas trail system
- Identify opportunities of stream habitat enhancement and/or restoration
- Complete construction prior to the start of construction of the Upper Berryessa Creek Project

Public Outreach

Community feedback and support was actively sought during the development of alternatives for the Project. The District held several public meetings at various local venues to discuss the project planning process and gather public input. Representatives from the City of Milpitas attended and were active participants during many project planning meetings, and District staff made presentations to City of Milpitas staff and the City Council. District staff has also met with resource agencies throughout the project planning process.

Staff-Recommended Alternative

The Project was divided into five project elements:

- ***Lower Berryessa Creek***, which extends from the confluence with Lower Penitencia Creek upstream to Calaveras Boulevard
- ***Tularcitos Creek***, extending from the confluence with Berryessa Creek to the upstream face of the crossing under I-680.
- ***Lower Calera Creek***, which extends from the confluence with Berryessa Creek to an existing drop structure approximately 3,000 feet upstream of the confluence.
- ***Upper Calera Creek Element 1***, extending from the existing drop structure upstream approximately 2,300 feet to the downstream face of an existing pedestrian bridge near Founders Lane.
- ***Upper Calera Creek Element 2***, which extends from the upper limits of Reach 1 upstream approximately 3,000 feet under I-680 and through Jose Hugera Adobe Park.

A range of potential alternatives were reviewed for each of these project elements. Conceptual alternatives were identified that could meet some or all of the project objectives and were qualitatively rated against key project criteria (see pg. 3-7). The conceptual alternatives were then screened down to identify feasible alternatives for further study. The feasible alternatives were rated using the District's Natural Flood Protection (NFP) objectives.

The staff-recommended alternative was identified after an evaluation using NFP objectives and engagement with the community and City of Milpitas staff. The staff-recommended alternative for each project element meets the project objectives, balances NFP objectives, and meets objectives identified by the City of Milpitas. The proposed project elements consist of the following:

- ***Lower Berryessa Creek:*** Reconstruct the existing levee on one side of the channel and replace the existing levee on the other side with a floodwall.
- ***Tularcitos Creek:*** Construct a stormwater pump station near the confluence with Berryessa Creek and construct short floodwalls where necessary to provide adequate freeboard.
- ***Lower Calera Creek:*** Reconfigure the channel and construct floodwalls on both banks.
- ***Upper Calera Creek Element 1:*** Construct floodwalls on both channel banks.
- ***Upper Calera Creek Element 2:*** Downstream of I-680, provide a bypass channel. Upstream of I-680, reconstruct portions of the existing channel at an existing drop structure and construct a floodwall on one side of the channel at the upper end of the project reach.

The proposed project is not expected to cause any significant changes to current maintenance to remove sediment from the creeks, although sediment removal costs and effort will decrease in areas where maintenance access is improved. However, new project elements (e.g. floodwalls) are estimated to increase maintenance costs by approximately $168,000 per year.

Project Cost, Financing and Schedule

The estimated design and construction capital cost for the proposed project is $48.5 million (2009 dollars). The flood protection improvements would be funded by the ad valorem property tax in the Watershed and Stream Stewardship Fund.

The proposed project design and construction would be performed in three phases:

Phase 1
This phase would consist of the design and construction of the Lower Berryessa Creek and Lower Calera Creek project elements. Construction of these elements must be completed prior to completion of the Upper Berryessa Creek Project. Design and construction of this phase is expected to be completed in 2012.

Phase 2
This phase would consist of design and construction of the Tularcitos Creek project element. Construction of this project element must be completed prior to the completion of the Upper Berryessa Creek Project. Design and construction of this phase is expected to be completed in 2014.

Phase 3
This phase would consist of design and construction of Upper Calera Creek Element 1 and Upper Calera Creek Element 2. Construction of these elements would not be affected by the Upper Berryessa Creek Project. The schedule for the completion of design and construction of this phase will vary depending on available funding.

CHAPTER 1. BACKGROUND

CHAPTER 1 BACKGROUND

The Lower Berryessa Creek Project Planning Study Report (PSR) presents the existing flood protection problems addressed by the Lower Berryessa Creek Project (Project). The PSR addresses the identified problems and includes a discussion of alternatives analyzed and staff recommended alternatives for each Project element.

1.1. Purpose of the Planning Study Report

This report presents the flood-related problems in the Project watershed. This capital improvement project was initiated as part of the Flood Protection and Stream Stewardship Program, which was described in the Clean Safe Creeks and Natural Flood Protection report, approved by the Board in 2000. This report includes the following:

- Background, problem definition, project objectives and public outreach (Chapter 1)
- Watershed description (Chapter 2)
- Formulation and evaluation of alternatives (Chapter 3)
- Staff-Recommended Alternative (Chapter 4)
- Description of maintenance program (Chapter 5)
- Project cost, funding and schedule (Chapter 6)
- Conclusions and recommendations (Chapter 7)

In addition to this report, a California Environmental Quality Act (CEQA) document will be prepared to address the potential environmental impacts of the Project. The CEQA document will contain a detailed discussion of the potential impacts and, if necessary, proposed mitigation measures. It will support decision making by the District and other responsible agencies.

1.2. Project Background

The Project is located in the City of Milpitas and consists of project elements on Lower Berryessa Creek and on two tributary creeks, Tularcitos and Calera Creeks, as shown in Figure 1-1.

1.2.1. Lower Berryessa Creek

Lower Berryessa Creek begins at the confluence of Lower Penitencia and Berryessa Creeks and extends upstream approximately 8,700 feet to the downstream face of the bridge crossing at Calaveras Boulevard. Existing levees on both sides of the creek, originally constructed in 1976, provide flood protection. The heights of these levees were increased by up to 1.5 feet in 1997 to provide design flood protection based on hydrology and hydraulics available at the time.

Previous studies[1,2,3,4,5] resulted in the following findings, summarized below:

- The existing channel cannot contain the design flows from the Upper Berryessa Creek Project.
- Generally, the levees are structurally stable. However, large sections of the levees are constructed with highly plastic clays that are subject to excessive shrinkage and swelling, which has caused erosion, sloughing and cracking to occur along significant portions of the levees. Continued cracking and slope erosion may undermine levee stability, eventually causing a major failure on some sections of the levee.
- To achieve long-term levee stability, the levee slopes should be flattened, or the unsuitable soil removed and the levees rebuilt.
- Without on-going and costly maintenance, the flood protection would be compromised by the cracking and slope erosion of expansive soils that would undermine the stability of the existing levees.
- Maintenance access roads do not meet District requirements.
- The levees have not been fully integrated into the City of Milpitas trail system.

1.2.2. Tularcitos Creek

Tularcitos Creek is a tributary to Berryessa Creek. The Tularcitos Creek Project reach extends from its confluence with Lower Berryessa Creek to the upstream face of the culvert crossing of I-680. The existing creek channel is an earthen trapezoidal channel with accumulated sediment and moderate vegetation growth in the low flow channel. Several roads and pedestrian bridges cross the creek. Most of the creek is adjacent to residential neighborhoods and the available right of way (ROW) is very constrained.

Flows in Berryessa Creek have a backwater effect on most of Tularcitos Creek. If improvements are made to Lower Berryessa Creek to contain increased flows resulting from future upstream improvements, the design water surface elevation in Berryessa Creek will increase and accentuate the backwater effect on Tularcitos Creek. A hydraulic model of Tularcitos Creek baseline conditions indicates that the peak design flow cannot be contained within the existing creek channel. This is due to both backwater effects from Berryessa Creek and inadequate channel capacity.

1.2.3. Calera Creek

Calera Creek is a tributary to Berryessa Creek. The creek is separated into three project elements for this PSR:

1 Nolte Associates and Harza Engineering, *Engineering Analysis of Berryessa Levees for City of Milpitas*, May, 1999

2 Memo from Mohammad Khan to Scott Katric, SCVWD, "*Geotechnical Investigations and Recommendations for Levee Repair along Berryessa Creek*", August 30, 1999

3 US Army Corps of Engineers Sacramento District, *Office Report Hydrology Berryessa Creek*, September 1982

4 SCVWD and US Army Corps of Engineers, *Berryessa Creek Watershed Hydrology Report*, April 2003 for Coyote Watershed Program.

5 City of Milpitas, *Berryessa Creek Trail and Coyote Creek Trail Feasibility Report – Administrative Draft,* March 30, 1999.

- Lower Calera Creek – which extends from the confluence with Lower Berryessa Creek to an existing drop structure approximately 3,000 feet upstream of the confluence with Berryessa Creek.

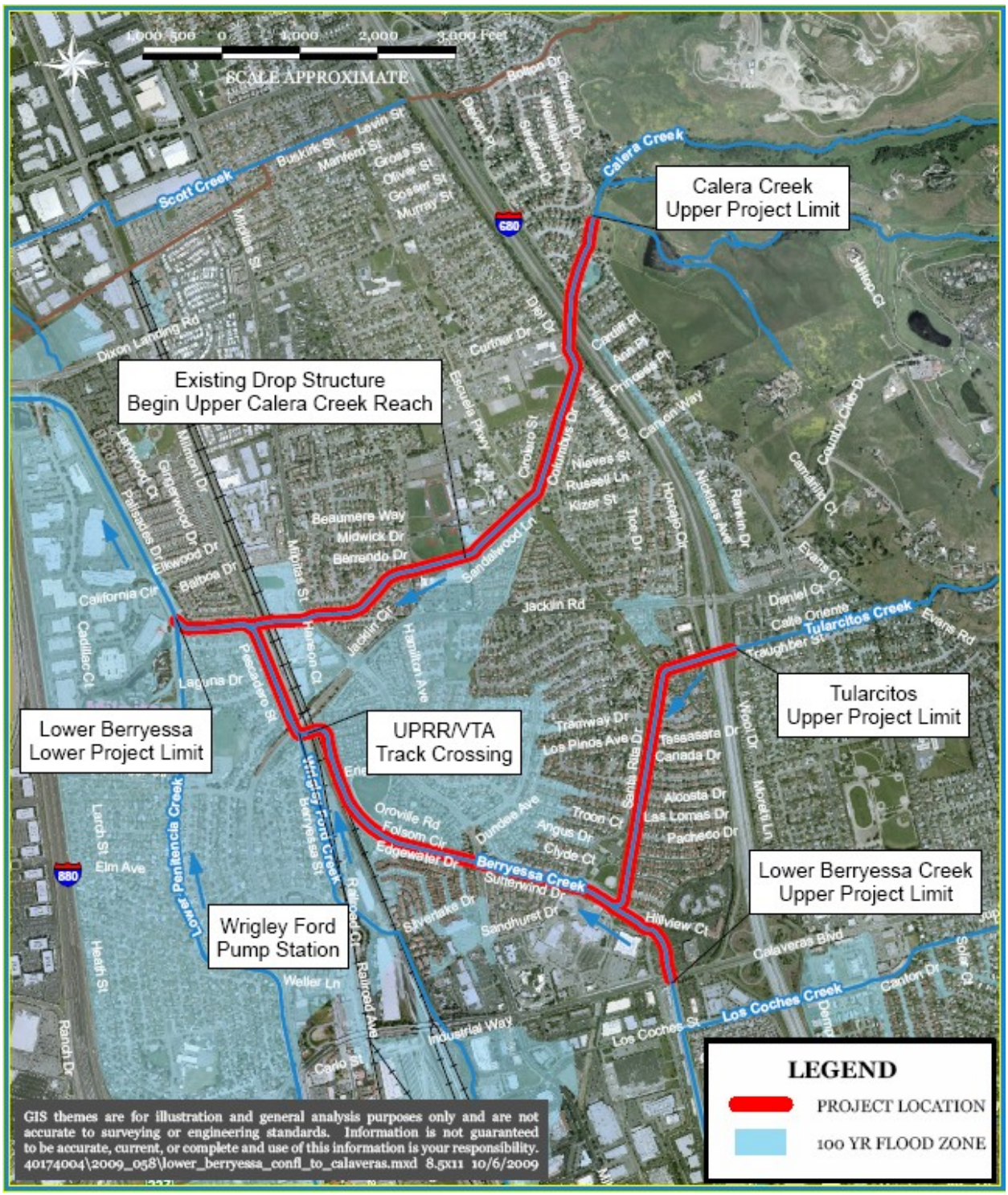
- Upper Calera Creek Element 1 – which begins at the existing drop structure, crosses Escuela Parkway and extends upstream to an existing pedestrian bridge near Founders Lane, for a total length of about 2,300 feet.

- Upper Calera Creek Element 2 – which begins at the upper limits of project element 1 at the existing pedestrian bridge and extends upstream approximately 3,000 feet, crossing both I-680 and N. Park Victoria Drive.

The majority of the existing creek channel is an earthen trapezoidal channel with accumulated sediment and moderate vegetation growth in the low flow channel. In the lower reach between the railroad crossing and North Milpitas Boulevard (approximately 470 feet in length), the channel is a rectangular concrete section. Several roads cross the creek. Most of the creek is adjacent to residential neighborhoods and the available ROW is very constrained.

Flows in Berryessa Creek have a backwater effect on Calera Creek that extends about 3,000 feet upstream of the two creek's confluence to an existing drop structure. If improvements are made to Lower Berryessa Creek to contain increased flows resulting from future upstream improvements, the design water surface elevation in Berryessa Creek will increase and accentuate the backwater effect on this downstream reach of Calera Creek. A hydraulic model of baseline conditions indicates that the peak design flow cannot be contained within the existing creek channel. This is due to backwater effects from Berryessa Creek on the downstream reach and inadequate channel capacity along most of the creek.

Figure 1-1: Lower Berryessa Creek Project Location Map



1.3. Problem Definition

The problems identified in the Project area include flooding, effects on local drainage conditions, substandard maintenance access, and deterioration of previous improvements. The problems associated with flooding are primarily due to increased flows in Berryessa Creek that will result from improvements upstream of the Project.

1.3.1. Creek Flooding

Historic and Recent Flooding

Detailed reports on flooding and flood related damages in Santa Clara County from 1982 to present were obtained from the District. Reports on flooding prior to 1982 were not available although other references identify historical flooding in Santa Clara County in 1899, 1911, 1931, 1937, 1940, 1941, 1950, 1952, 1955, 1958, 1962, 1963, 1968, 1973, and 1980. Later flooding in 1982, 1983, 1986, 1995, 1997, and 1998 is documented in District flood reports. Prepared immediately following each flood event, these flood reports provide flood maps, damage estimates, rainfall and streamflow data from gages on streams affected by flooding.

A review of these flood reports indicates that flooding along Berryessa Creek occurred in 1982, 1983, and 1998. No flooding was reported on Berryessa Creek during the 1986, 1995, and 1997 floods that occurred elsewhere in Santa Clara County. Flooding on Berryessa Creek in 1982 was minimal, affecting only a small area about 1,000 feet upstream of Calaveras Boulevard and causing no damage. Yet, widespread flooding did occur immediately downstream of Berryessa Creek on both Lower Penitencia Creek and Coyote Creek.

Flooding on Berryessa Creek in 1983 was much more damaging and widespread. The creek levees were overtopped at multiple locations, including upstream of Old Piedmont Road, upstream and downstream of Montague Expressway, and at the confluence of Berryessa Creek with both Piedmont Creek and Arroyo de Los Coches. Extensive flooding also occurred on Lower Penitencia Creek both upstream and downstream of the Berryessa Creek confluence. Flooding in 1998 occurred at the confluence of Berryessa Creek with Calera Creek. Flood damage was reported on several streets north of the confluence.

FEMA/District 100-year flood maps indicate flooding along portions of Lower Berryessa and Calera Creeks but no overtopping on Tularcitos Creek. Refer to Figure 1-2. No reports of flooding along Calera Creek or Tularcitos Creek were discovered in the course of performing this study.

Future Flooding Potential

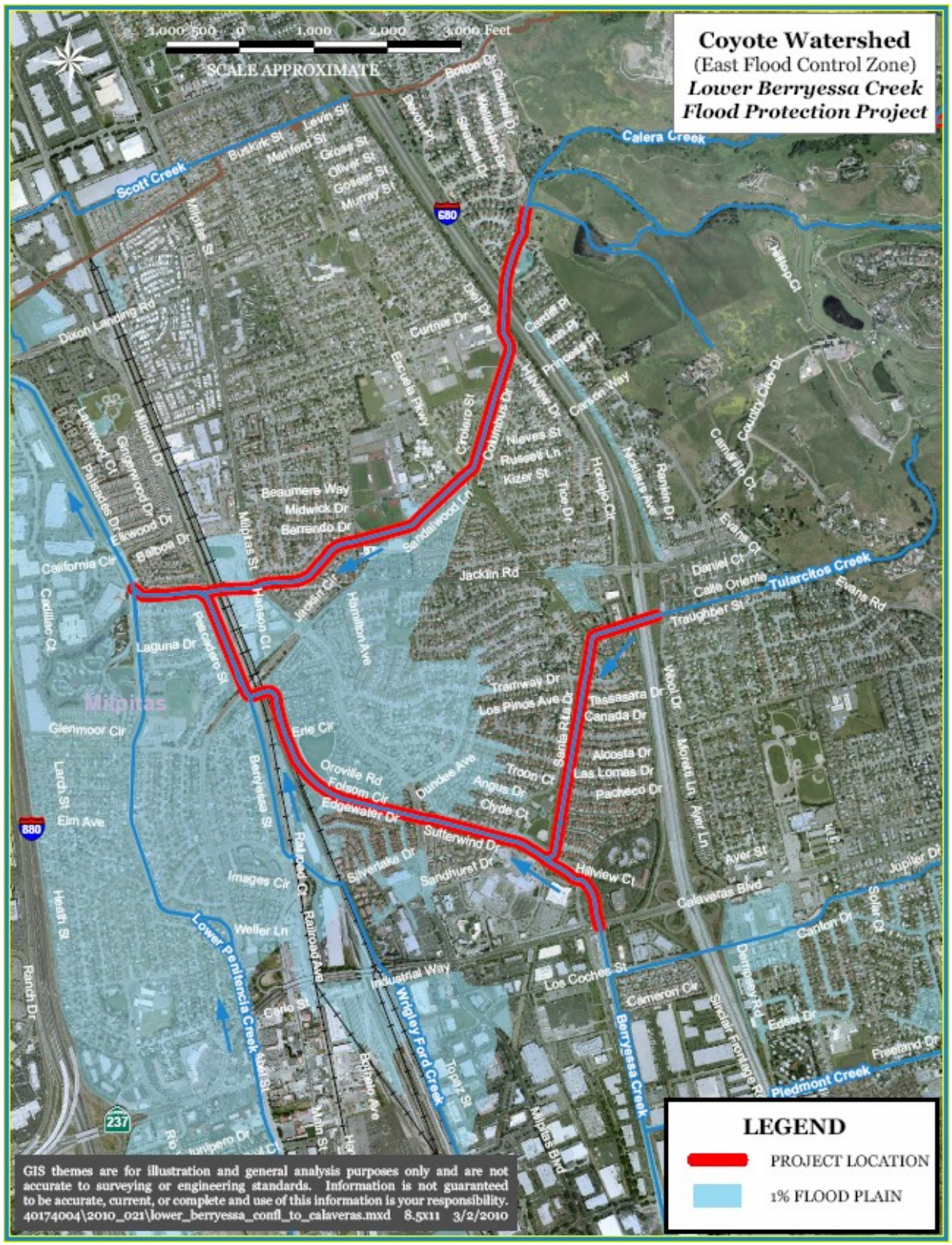
The Corps of Engineers is currently developing design documents for channel improvements on Berryessa Creek upstream of Calaveras Boulevard (Upper Berryessa Creek). These upstream improvements will increase the flows in Lower Berryessa Creek during extreme storm events, exacerbating potential flood damage. Flood protection improvements on Lower Berryessa Creek to contain these increased flows would increase the water surface elevation (or hydraulic grade line, HGL) in the creek. This increased HGL will increase backwater effects on Calera Creek and Tularcitos Creek. Even without improvements to Berryessa Creek, backwater impacts on Calera Creek currently extend upstream to the drop structure, approximately 3,000 feet upstream of the confluence with Berryessa, and on Tularcitos Creek up to I-680.

1.3.2. Local Drainage Conditions

The City of Milpitas completed a storm drain master plan in 2001[6] that included Berryessa, Tularcitos and Calera Creek watersheds. Portions of the creeks within the District's jurisdiction were identified as undersized with potential flooding impacts to the surrounding community. However, the master plan concludes that the local city drainage system for the most part is adequate, identifying only low priority storm drainage improvement projects.

[6] Schaaf & Wheeler, *City of Milpitas Storm Drain Master Plan*, July 2001

Figure 1-2: Lower Berryessa Creek Project 1% Floodplain Map



1.3.3. Maintenance Access

Inadequate access makes maintenance more difficult, costly and time-consuming. The District's maintenance standards require 18-foot minimum maintenance road widths, with maintenance roads located on top of all levees and additional lower service roads, one on each side of the low-flow channel, wherever possible.

Lower Berryessa Creek has roadways on top of the levees that vary between 10 and 18 feet in width. Lower service roads exist only along portions of the creek, and many of these roads are in poor condition.

Tularcitos Creek has gravel access roads on both sides of the channel that range in width from approximately 8 to 14 feet.

Maintenance access roads on Calera Creek vary along the creek as in Table 1-1.

Table 1-1: Calera Creek Maintenance Access Roads

From	To	Maintenance Access Roads
Confluence with Berryessa Creek	N. Milpitas Boulevard	No access roads
N. Milpitas Boulevard	Drop Structure	Both sides of channel, width ranges from approximately 8 to 12 feet wide
Drop Structure	Escuela Boulevard	South side of channel only, approximately 12 feet wide
Escuela Boulevard	Pedestrian Bridge (near Founders Lane)	Both sides of channel, approximately 12 feet wide
Pedestrian Bridge	I-680	No access roads
I-680	Jose Hugera Park	West site of channel, width meets District's standard

1.3.4. Deterioration of Previous Improvements

Lower Berryessa Creek is a manmade channel that was constructed in its current location by the District in 1976. Located in an urbanized area, the creek has levees with maintenance roads on top on each side of the channel and exhibits a uniform compound trapezoidal cross section with lower maintenance roads on either side of a low flow channel. The heights of these levees were

raised by up to 1.5 feet in 1997, between the railroad crossing and Hillview drive, to provide 100-year flood protection based on hydrology and hydraulics available at the time.

Generally, the levees are structurally stable. However, large sections of the levees are constructed with highly plastic clays that are subject to excessive shrinkage and swelling, which has caused erosion, sloughing and cracking to occur along significant portions of the levees. Without costly on-going maintenance, continued cracking and slope erosion will undermine levee stability, eventually causing a major failure on some sections of the levee.

Tularcitos Creek and the majority of Calera Creek are manmade channels. There has been some minor erosion of the channel banks requiring periodic maintenance.

1.4. Project Objectives

The objectives of the District's Lower Berryessa Creek Project are to:

- Provide flood protection for the design flood event
- Improve access for long-term channel maintenance
- Incorporate opportunities to integrate levees with the City of Milpitas trail system
- Identify opportunities for stream habitat enhancement and/or restoration
- Complete construction prior to the start of construction of Upstream Berryessa Creek Project

The Project should also meet the objectives of the District's Flood Protection and Stream Stewardship Program, specifically:

- Homes, schools, businesses and transportation networks are protected from flooding
- There is clean, safe water in our creeks and bays
- Healthy creek and bay ecosystems are protected, enhanced or restored as determined appropriate by the District's Board of Directors
- There are additional open spaces, trails and parks along creeks and in the watersheds when reasonable and appropriate.

1.5. Cities and Other Major Property Owners within the Watershed

1.5.1. City of Milpitas

The entire Project, including Berryessa Creek, Tularcitos Creek and Calera Creek, lies within the City of Milpitas. Existing conditions result in numerous properties being located within the 100-year flood plain. The levees along Lower Berryessa Creek are also along the alignment of a planned City trail system.

1.5.2. Union Pacific Railroad (UPRR)/Santa Clara Valley Transportation Authority (VTA)

The VTA is constructing a box culvert to replace two railroad tracks that cross Berryessa Creek near Abel Street, as indicated on Figure 1-1. The District and VTA entered into a cooperative agreement for the design and construction of these improvements.

1.5.3. San Francisco Public Utilities Commission

The Hetch Hetchy water mains cross Berryessa Creek at the confluence with Tularcitos Creek, and Calera Creek at Escuela Parkway. Existing construction and ROW conditions place constraints on flood protection improvements in the vicinity of these mains, such as access requirements for maintenance, limits of excavations, and requirements for scour or erosion protection.

1.5.4. Milpitas Unified School District

Milpitas High School and Thomas Russell Middle School are located adjacent to Calera Creek and present design and construction constraints to flood protection improvements. Potential constraints include limited ROW, limits on construction activities while school is in session, and school safety considerations.

1.5.5. Milpitas City Parks

Several City parks are located adjacent to Project elements.

- Peter T. Gill Park is located adjacent to Tularcitos Creek near the confluence with Berryessa Creek
- Hugera Adobe Park is located adjacent to Calera Creek just upstream of the I-680 crossing.

1.6. Public Outreach

1.6.1. Public Meetings

Public Outreach Meetings were held at crucial project milestones to solicit input and inform the public on the progress. In each case, the District invited all property owners and residents living within 1 mile of the Project.

- **Problem Definition, Objectives, and Conceptual Alternatives (October 2003):** First Public meeting to present the problem definition, project objectives and discuss possible alternative solutions.
- **Evaluation of Feasible Alternatives (March 2004):** Second Public Meeting to review the selected six feasible alternatives for Lower Berryessa Creek.

- **Problem Definition, Objectives, and Feasible Alternatives – Calera and Tularcitos Creeks (September 2005):** Third Public Meeting to review potential Solutions for Calera and Tularcitos Creeks.
- **Further Evaluation of Feasible Alternatives – Berryessa, Calera and Tularcitos Creeks (October 2007):** Fourth Public Meeting to review the selected four feasible alternatives for Lower Berryessa, Calera and Tularcitos Creeks.

1.6.2 Outreach to Cities

The Project is within the City of Milpitas limits and the staff-recommended alternative for improvements will have a significant impact on the City and its residents. The District and the City of Milpitas staff have met several times to discuss potential benefits and impacts of the proposed alternative improvements on Berryessa, Calera and Tularcitos Creeks.

- September 2003: Workshop to screen conceptual alternatives.
- December 2003: Workshop to evaluate feasible alternatives and screen to six feasible alternatives.
- May 2004: Workshop to evaluate feasible alternatives and screen to four feasible alternatives for further study.
- December 2006: Meeting with City of Milpitas staff and VTA to discuss Lower Berryessa Creek alternatives.
- June 2007: Workshop to evaluate feasible alternatives and screen to four feasible alternatives for further study.
- December 2008: Meeting with City of Milpitas staff to review four feasible alternatives developed by the screening process for Lower Berryessa, Calera, and Tularcitos Creeks.
- February 2009: Meeting with City of Milpitas staff to review four selected feasible alternatives for Berryessa, Calera, and Tularcitos Creeks and prepare for presentation to City of Milpitas Council.
- April 2009: District presentation to City of Milpitas Council on staff-recommended alternatives for the various Project elements.
- August 2009: District mailed a letter to residents and Home Owner Associations providing an update on the status of the project and asked for input from residents.

CHAPTER 2. WATERSHED DESCRIPTION

CHAPTER 2 WATERSHED DESCRIPTION

This chapter provides a description of the Project watershed and its three creeks, Lower Berryessa Creek, Calera Creek and Tularcitos Creek.

2.1. Watershed Description

2.1.1. Size

The Berryessa Creek drainage basin is located northeast of San Jose, California. The basin is located immediately north of the Upper Penitencia Creek drainage basin. Berryessa Creek flows west out of the foothills of the Diablo Range in Santa Clara County, and then continues in a westerly direction through the southern portion of the City of Milpitas. The creek flows north through the City of Milpitas, joining Lower Penitencia Creek approximately 4,400 feet upstream of the confluence of Lower Penitencia Creek and Coyote Creek. Coyote Creek enters the San Francisco Bay approximately 10 miles northwest of downtown San Jose. The Berryessa Creek drainage basin encompasses 22.4 square miles of rural and urban land upstream of its confluence with Lower Penitencia Creek. The Lower Penitencia Creek basin, at its confluence with Coyote Creek, drains approximately 29 square miles. Ground elevations in the basin range from 2,600 feet above mean sea level (MSL) in the foothills to 10 feet above MSL at the confluence with Coyote Creek.

2.1.2. Climate

The Berryessa Creek basin lies within a region that has a mild Mediterranean climate. This is characterized by almost all of the rainfall occurring between November and early April, and mild temperatures that are rarely below freezing during the winter and seldom exceed 100 degrees during the summer. The mean annual precipitation at the San Jose station is 14.42 inches, with the month of June being the driest and January being the wettest. Precipitation events in the Berryessa Creek basin are predominately a result of either orographic (associated with the presence of mountains) or cyclonic effects. Orographic storms occur when moist air rises, cools and condenses as it moves over the Diablo mountain range on the east side of the basin. Cyclonic storms are the result of air masses moving from regions of higher barometric pressure to lower pressure zones. Additionally, cyclonic storms may be the result of frontal activity. Broad bands of low intensity rainfall are associated with warm fronts, while higher intensity rainfall is associated with cold fronts. Cloudburst storms or convective type storms with intense central rain and limited spatial distribution rarely occur in the basin.

2.1.3. Flooding and Drainage

Flooding resulting from intense widespread precipitation over the Santa Clara Valley and Diablo Range typically coincides with peak seasonal rainfall. These floods are characterized by high

peak flows of moderate durations which are intensified when the ground is saturated. The storms that lead to flooding are typically cyclonic storms originating in the Pacific Ocean. Runoff from urban areas in the basin is conveyed to main channels by municipal storm drainage systems. Streets serve as temporary collection basins upstream of the storm drainage systems. During extreme rainfall events, when flows exceed the capacity of the storm drainage system, excess water flows overland and down the streets. Localized flooding in the urban portions of the basin results from undersized storm drains and sediment or debris clogging the storm drain inlets. More damaging flooding is induced by inadequate channel capacities in major collection and conveyance systems such as Berryessa Creek.

2.2. Creek Descriptions

2.2.1. Lower Berryessa Creek

The Lower Berryessa Creek Project reach extends from the confluence with Lower Penitencia Creek upstream to Calaveras Boulevard. This reach of the creek has levees and maintenance roads on each side and exhibits a uniform compound trapezoidal cross-section with lower maintenance roads on either side of a low flow channel. Two areas are concrete lined, a 700-foot length where the channel makes two 90-degree turns immediately upstream and downstream of the UPRR/VTA railroad bridges, and a 210-foot length at the Tularcitos Creek confluence over the Hetch-Hetchy water mains. Both concrete-lined channel lengths exhibit a simple trapezoidal channel cross-section with no maintenance roads. A total of six bridges cross the creek within the project reach. Listed in downstream order of occurrence, they are: Calaveras Boulevard, North Hillview Drive, North Milpitas Boulevard, two adjacent railroad bridges, and North Abel Street. The Calaveras Boulevard Bridge and the two existing railroad bridges significantly impede flood flows. The other bridges are either at or above the levee top elevation and do not significantly affect flow conveyance. Both the Calaveras Boulevard Bridge and the existing railroad bridge openings are partially blocked with sediment and vegetation.

There are very few trees along this section of Lower Berryessa Creek. Grasses, tules, and low shrubs are typical vegetation for most areas. None of the riparian vegetation provides significant shading to the creek channel. A more detailed description of the existing channel characteristics can be found in Appendix A

2.2.2. Tularcitos Creek

The Tularcitos Creek Project reach extends from the confluence with Lower Berryessa Creek to the upstream face of the culvert crossing of I-680. The channel consists of a concrete trapezoidal channel from the confluence with Berryessa creek upstream to Paseo Refugio. Upstream of Paseo Refugio, the creek consists of an earthen trapezoidal channel with grassy side slopes and a relatively narrow low-flow bottom. The majority of the channel has narrow access roads on both sides. There are four road culvert crossings within the project reach. Listed in downstream order

of occurrence they are: I-680, North Hillview Drive, Tramway Drive and Paseo Refugio. In addition, there are four pedestrian bridge crossings.

Grasses, tules, and low shrubs are typical vegetation for most areas. A more detailed description of the existing channel characteristics can be found in Appendix A

2.2.3. Calera Creek

Calera Creek is separated into three project elements for this PSR: Lower Calera Creek, Upper Calera Creek Element 1 and Upper Calera Creek Element 2, as shown in Figure 2-1.

Lower Calera Creek

Lower Calera Creek extends from the confluence with Lower Berryessa Creek to an existing drop structure approximately 3,000 feet upstream of the confluence with Berryessa Creek. From the confluence with Berryessa Creek upstream to the UPRR railroad crossing, the channel is an earthen trapezoidal section with some sandbag slope stabilization. Upstream from the railroad crossing to North Milpitas Boulevard, the creek is contained in a vertical walled concrete channel. Upstream of Milpitas Boulevard to the drop structure, the creek consists of an earthen trapezoidal channel with grassy side slopes and a relatively narrow low flow bottom.

The majority of the channel has narrow access roads on both sides. The existing energy-dissipater drop structure is a concrete structure approximately 16 feet in width with concrete baffles with a rise of slightly over 10 feet. There are three culvert crossings along the Lower Calera Creek Reach: Arizona Avenue, North Milpitas Boulevard and the UPRR railroad crossing.

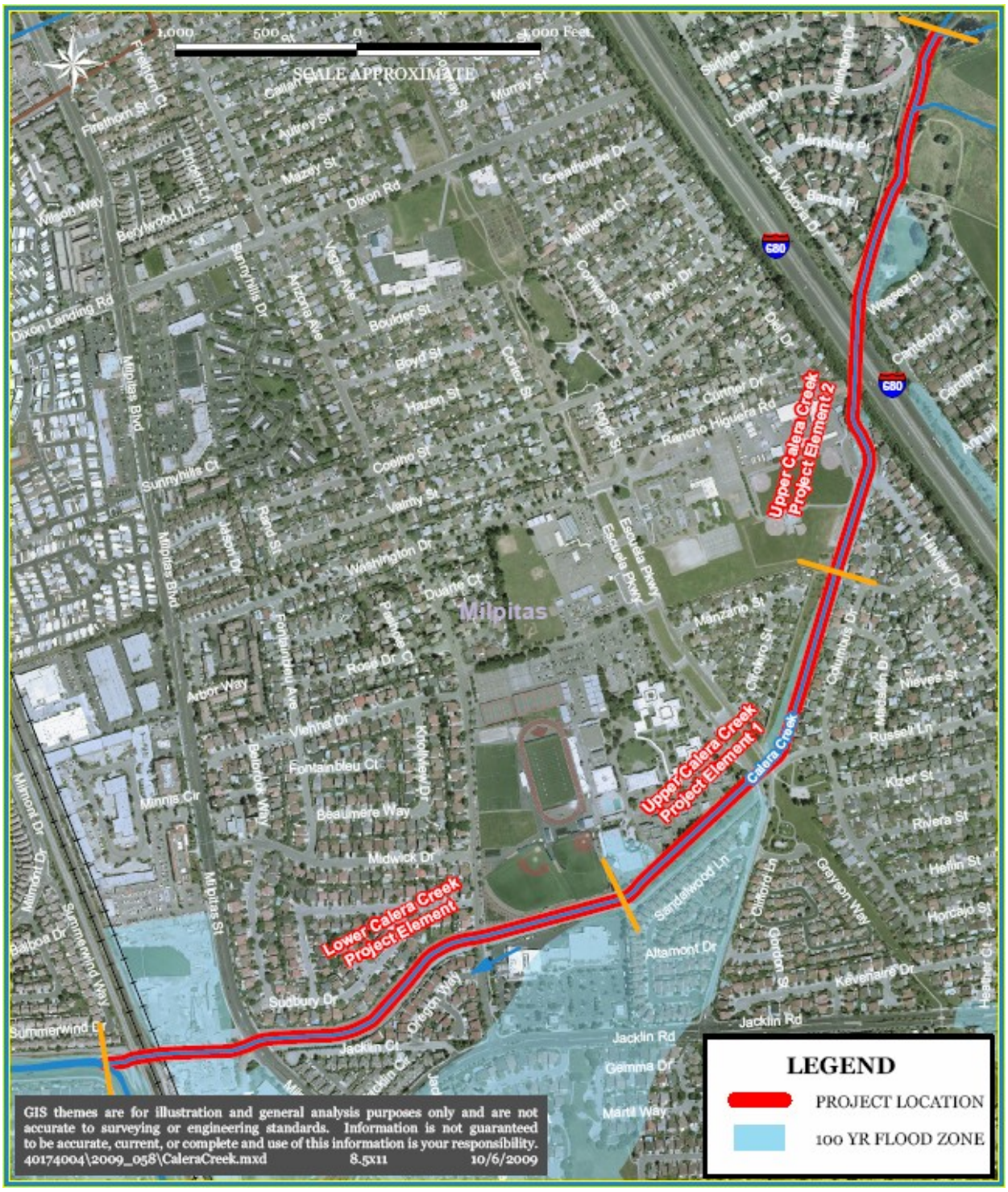
Grasses, tules, and low shrubs are typical vegetation for most areas. A more detailed description of the existing channel characteristics can be found in Appendix A

Upper Calera Creek Element 1

Upper Calera Creek Element 1 begins at the existing drop structure, crosses Escuela Parkway and extends upstream to an existing pedestrian bridge near Founders Lane, for a total length of about 2,300 feet. The reach consists of a low flow channel (approximately 10 to 20-ft wide) within a broader floodplain (approximately 100- to 130-ft wide). The floodplain upstream of Escuela Parkway is more defined than in the downstream reach.

There is a culvert crossing at Escuela Boulevard. Moderate sedimentation and vegetation occur in the channel with mature trees along overbanks below Escuela Boulevard. The reach below Escuela Boulevard has a narrow access road on the east side of the channel. Narrow access roads are located on both sides of the channel upstream of Escuela Boulevard. A more detailed description of the existing channel characteristics can be found in Appendix A

Figure 2-1: Map of Calera Creek Tributary



Upper Calera Creek Element 2

Upper Calera Creek Element 2 begins at the upper limits of element 1 at the existing pedestrian bridge and extends upstream approximately 3,000 feet, crossing both I-680 and N. Park Victoria Drive. Upstream of the pedestrian bridge, the creek becomes much narrower and steeper with a narrow ROW of 60 feet. Access for maintenance of Upper Calera Creek Reach 2 is limited below I-680. Although there are flat overbanks approximately 10-feet in width within the existing ROW, they are overgrown with mature trees that currently prevent maintenance access to this reach of the channel. Upstream of I-680 through Jose Hugera Adobe Park, the channel remains relatively restricted with an existing drop structure that creates a sudden channel grade change of approximately 5 feet near the upper (north) end of the park. Upstream of the park the channel is not well defined and is located in a relatively wide grassy swale. It should be noted that the channel upstream of I-680 is not located in District ROW. The District has access ROW adjacent to the west side of the channel but the channel itself is within the City park property and on private property.

2.3. Watershed Hydrology

A hydrologic study[7] (Appendix B) was completed in 2003 for the contributing watershed, and provides information on the hydrology methodology and design flow calculations. This hydrologic study accounts for the Upper Berryessa Creek Project, which will result in greater flows in Lower Berryessa Creek.

In 2006, the Corps of Engineers[8] and the District modified the design flows as developed by the earlier hydrology study to account for possible future drainage improvements along tributaries to Berryessa Creek. The updated values were further refined by the Corps and the District to account for future adjustments in statistical hydrology and hydraulic modeling techniques. Table 2-1 summarizes the modified 100-year flows that were used for this planning study report.

[7] Northwest Hydraulic Consultants, *Berryessa Creek Watershed Hydrology Report, April 2003 and Addendum 1,* October 2006

[8] The U.S. Army Corps of Engineers (Corps) and District design flows are documented in series of email messages:

- From Scott Miner, Corps to Stephen Ferranti, SCVWD dated July 15 2008
- From Krey Price, Tetra Tech to Scott Miner, Corps dated July 21 2008
- From Scott Miner, Corps to Stephen Ferranti, SCVWD dated July 21, 2008
- From Tony Ndah, SCVWD to Rick Jorgensen, W&K dated July 22, 2008

Table 2-1: 24 Hour, 100-Year Design Flows

Location	Modified 100-Year Design Flow used for Project Analysis (cfs)
Lower Penitencia Creek Above Confluence with Coyote Creek	9,050
Lower Penitencia Creek Below Confluence with Berryessa Creek	8,850
Berryessa Creek at Downstream End Immediately Above Confluence with Lower Penitencia Creek	7,200
Berryessa Creek at North Abel Street Below Confluence with Wrigley-Ford Ditch	6,900
Berryessa Creek Berryessa Pump Station	5,960
Berryessa Creek Below Confluence with Tularcitos Creek	5,950
Berryessa Creek at Calaveras Boulevard	5,150
Berryessa Creek Below Confluence with Piedmont Creek	4,010
Berryessa Creek at Yosemite Rd	3,000
Berryessa Creek at Landess Road	2,810
Berryessa Creek Below Confluence with Sierra Creek (Morrill Rd)	2,250
Berryessa Creek Below Confluence with Crosley Creek	1,875
Berryessa Creek Below Confluence with Sweigert Creek	1,640
Berryessa Creek at Old Piedmont Road	1,540
Piedmont Creek at Mouth	1,200
Arroyo de Los Coches at Mouth	1,330
Tularcitos Creek at Mouth	845
Calera Creek at Mouth	880

2.4. Watershed Geology

The geology of the Berryessa Creek watershed consists mainly of Tertiary and Quaternary age sedimentary rocks in mountainous areas and semi-consolidated to unconsolidated Quaternary age sediments in the Santa Clara Valley. Rocks in the mountainous part of the basin are mainly composed of marine and nonmarine sandstone, siltstone, and shale. Minor tuff, claystone and partially to completely serpentinized ultramafic rocks outcrop in the basin at a few locations. Geology in the Santa Clara Valley portion of the watershed is limited to Quaternary age, semi-

consolidated alluvium near the base of Los Buellis Hills and younger, unconsolidated alluvium further downslope. Alluvial sediments are largely medium to fine-grained, consisting primarily of moderately to poorly sorted fine sand, silt, and clay.

Faulting in the Berryessa Creek watershed trends in a northwest - southeast orientation that follows the structural alignment of the Coast Range. Major faults in the basin include the Hayward Fault Zone and the Calaveras Fault. Both faults are seismically active and have experienced numerous large earthquakes (Magnitude >5) in the historical record. Future large earthquakes along both faults are expected. In addition to these major faults, numerous smaller faults cross through the Berryessa Creek watershed, all of them in a northwest - southeast orientation. Future large earthquakes in the vicinity of Berryessa Creek would likely increase landslide activity in the watershed, potentially increasing basin sediment yield.

A prominent geomorphic feature of the upland basin is the unstable "canyon" reach of Berryessa Creek extending from about 1,500 feet to 4,000 feet upstream of Old Piedmont Road. This reach, which appears to lie within the Hayward-Crosley fault zone, is characterized by a very steep longitudinal profile, unstable steep bare side slopes and active landslide scarps. The underlying bedrock is composed of poorly consolidated, highly fractured Tertiary age rocks that contain swelling clays. This zone provides a plentiful supply of sediment to the creek channel, which is tightly confined by encroaching slide material. Sediment yields from such areas are among the highest in the San Francisco Bay region.

The Santa Clara Valley experienced substantial land subsidence due to groundwater overdraft from approximately 1900 to 1965, the year that state water deliveries began to arrive in the San Jose area. Measured land subsidence recorded in downtown San Jose at the corner of North 1st Street and St. James Street was 14.1 feet from 1906 to 1995, with 13.0 feet (92% of total) occurring before 1966. Berryessa Creek is located in the outer margin of the zone affected by land subsidence and experienced between 0 and 4 feet of subsidence from 1900 to 1967.

More detailed geologic information can be found in the geotechnical investigation reports prepared for each of the project elements.[9,10,11]

2.5. Historical Stream Channel

The alignment of Berryessa Creek has undergone very significant changes since the middle of the 19th century (Figure 2-2). Most of these changes resulted from human activities, including channel confinement and channel realignment to divert flood flows away from agricultural and urban areas. Prior to these modifications, Berryessa Creek exited the Los Buellis Hills and

9 Lowney Associates, *Preliminary Geotechnical Report, Berryessa Creek Levees Project*, August 28, 2001

10 Lowney Associates, *Geotechnical Report, Lower Berryessa Creek Project, Calera and Tularcitos Creek Reaches*, October 4, 2005

11 TRC, *Draft Geotechnical Investigation, Lower Berryessa Creek Project, Upper Calera Creek Reaches 1 & 2*, October 29, 2008

flowed out onto an alluvial fan. Alluvial fans are defined as outspread, sloping masses of alluvium deposited by streams. They are typically located in arid or semi-arid regions.

Alluvial fans typically form when a stream with a high sediment load exits a steep, mountainous area and flows into a more gradually sloping valley. The decline in slope causes sediment to deposit in the creek during flood flows, resulting in a decrease in channel capacity with distance downstream. As channel capacity declines, flood flows break out of the main channel and spread out onto the unconfined alluvial fan surface, causing flooding and sediment deposition over large areas. Although all of the alluvial fan is formed by sediment deposition from stream flows, only part of the fan is active at any given time. Channel avulsion will usually change the area of active fan building from one part of the fan to another over time. This generally occurs when the majority of flood flows shift into a distributary channel and the main channel is abandoned. The abrupt change in channel alignment from 1866-79 to 1899 shown in Figure 2-2 may have been due to channel avulsion. The 1899 channel planform also shows three arrows emerging from the downstream end of Berryessa Creek. These arrows were present in 1899 mapping and identify the transition from a single creek channel to the distributary flow pattern characteristic of alluvial fan systems.

By 1943, Berryessa Creek extended much further downstream, reaching as far as Lower Penitencia Creek (Figure 2-2). Examination of historical aerial photographs shows orchards along the creek during this period. Given the relatively short length of Berryessa Creek in 1866-79 and in 1899, it is likely that the creek had been lengthened by human activity prior to 1943 to either divert flood flows away from orchard areas, provide flood control, or supply irrigation water. Regional land subsidence that occurred throughout Santa Clara Valley may also have played a role in increasing stream length. Although the amount of land subsidence that had occurred in the Milpitas area by 1943 cannot be determined exactly, it can be inferred from other data that between 0 and 3 feet of subsidence occurred in the vicinity of Berryessa Creek by 1943. Land subsidence increased with distance toward the central Santa Clara Valley. Thus, Berryessa Creek experienced very little land subsidence near the foothills and the greatest amount of subsidence in the lower part of the creek. Land subsidence affects area streams by creating a drop in base level, causing the streams to become steeper. This results in an increase in stream energy and subsequent channel degradation as streams adjust to a new base level. In the case of alluvial fan systems, this would result in an overall lengthening of the stream channel.

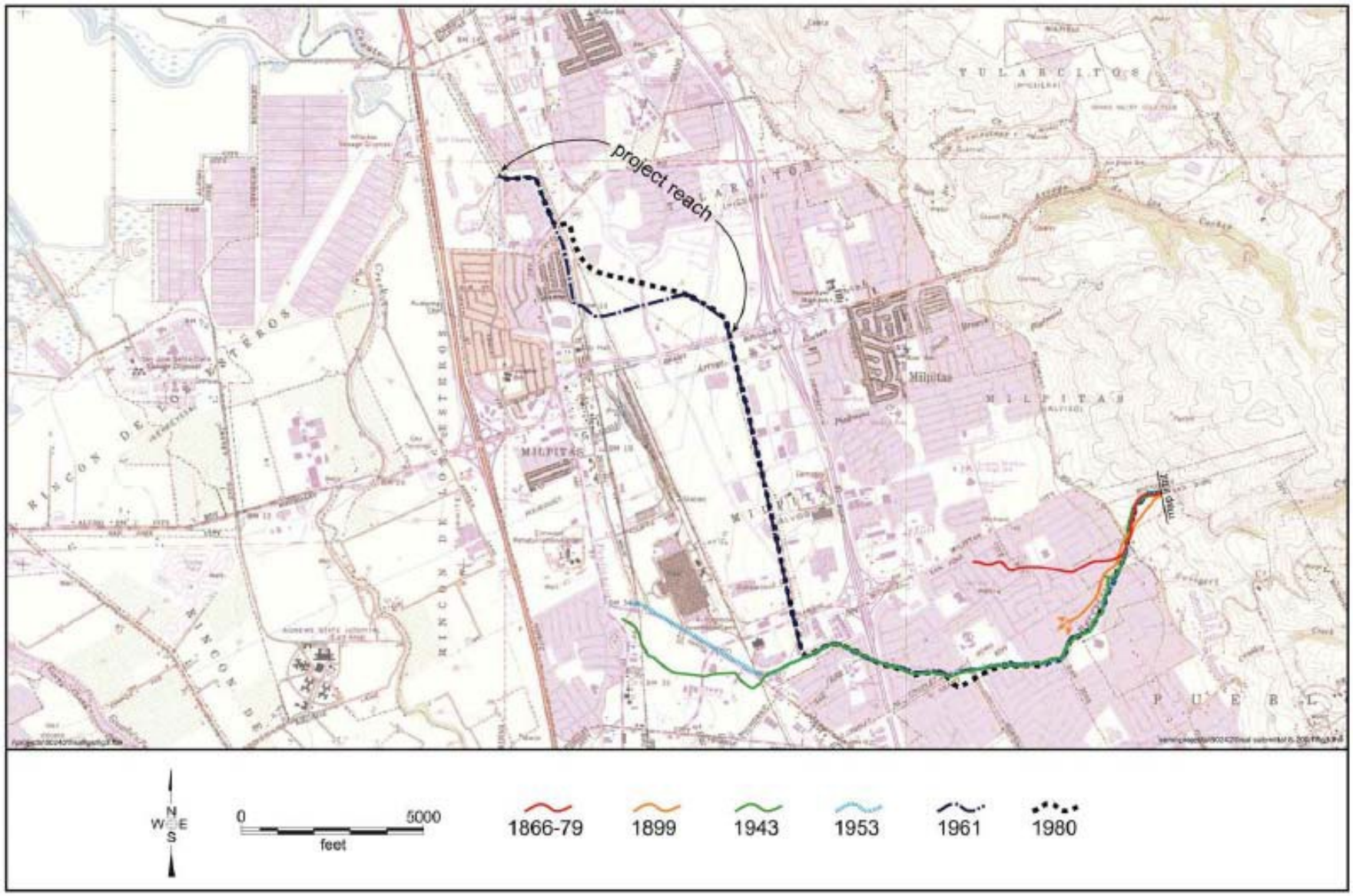
Major changes in channel alignment from 1943 to 1980 in Figure 2-2 were caused by human modifications to Berryessa Creek for flood control purposes, mainly for the protection of growing residential and light industrial areas that had largely replaced orchards by the 1970's. The most significant modification to Berryessa Creek occurred between 1953 and 1961 when the creek was realigned to flow northward. As a result, by 1961 the confluence of Berryessa Creek with Lower Penitencia Creek was shifted more than 2 miles downstream. Channel realignment observed in the project reach between 1961 and 1980 occurred in 1976 as part of a District flood

control program. The 1980 channel alignment in Figure 2-2 reflects the current configuration of Berryessa Creek.

Channel realignment is also observed on tributaries of Berryessa Creek. 1899 mapping shows no tributaries to Berryessa Creek in Santa Clara Valley. Instead, Sweigert, Crosley, Sierra, and Piedmont Creeks flow downslope and terminate less than a half mile downstream of the border between Santa Clara Valley and the Los Buellis Hills. Each creek shows three arrows emerging from its downstream end, indicative of the distributary channel pattern associated with an alluvial fan. By 1980, Sweigert, Crosley, Sierra, and Piedmont Creeks had been lengthened and realigned to flow into Berryessa Creek Other major tributaries to Berryessa Creek, namely Calera Creek and Arroyo de los Coches, extend downstream to Lower Penitencia Creek in 1899 mapping. Today, these creeks are intercepted by the existing Berryessa Creek alignment.

When compared to early maps from the late 1800's, the present Berryessa Creek alluvial fan surface appears very different. Land use on the fan is almost entirely urbanized and all but the largest flood flows are now confined to the Berryessa Creek channel. Natural alluvial fan building processes have ceased. Instead, most flood flows are now confined to the creek channel and conveyed downstream to Coyote Creek.

Figure 2-2: Historical Planform Shift Map



2.6. Erosion and Sedimentation

2.6.1. Lower Berryessa Creek

The project reach is located in an actively aggrading section of Berryessa Creek. During high flows, sediment deposits throughout the project reach, raise the channel bed elevation and decrease channel flow conveyance capacity. Sedimentation in the downstream 1,200 feet of the channel is also affected by tidal action.. As a result, regular maintenance by the District is required to remove sediment and maintain channel capacity.

Large quantities of sediment and debris have been removed from Berryessa Creek by District crews in an ongoing effort to maintain flow capacity in the channel. The volume of sediment removed from the project reach each year is highly variable, ranging from as high as 33,040 yd^3 to as low as no sediment removal. The average annual amount of sediment removed from the project reach during the period of record (1981 to 2008) is approximately 7,500 yd^3 or 4,500 yd^3/mi/yr. When applied uniformly over the entire channel bed in the project reach, this sediment volume yields a reach average of 5 to 6 inches of sediment accumulation per year. Thus, large flood events which deposit sediment loads much higher than the average could result in more than 1 or 2 feet of sediment accumulation in some parts of the project reach. In contrast, dry years with no high flow would result in limited sedimentation, caused by both fluvial processes and by tidal action in the downstream end of the project reach.

Stream bank erosion is largely absent from the project reach, a condition that is expected to continue into the future. The lack of significant bank erosion, other than that observed downstream of Tularcitos Creek, is due primarily to the depositional nature of the project reach, channel maintenance activities, and to cohesive bank sediments that are resistant to erosion. Future bank erosion, if it occurs, is expected to proceed at a very slow rate due to the predominantly cohesive bank sediments found in the project reach.

2.6.2. Tularcitos Creek

The majority of the existing creek channel is an earthen trapezoidal channel, originally constructed with 1.5:1 side slopes and a bottom width of approximately 21 feet. The low flow channel has been encroached with sediment and is narrower than the original constructed width in many instances.

The channel has undergone some vegetation and sediment removal in the past but no regularly scheduled maintenance occurs. It does not appear that sedimentation is a significant problem as even without scheduled maintenance, the sedimentation rate is minor.

Stream bank erosion is largely absent from the project reach, a condition that is expected to continue into the future. The lack of significant bank erosion is due primarily to the depositional nature of the project reach, channel maintenance activities, and to cohesive bank sediments that

are resistant to erosion. Future bank erosion, if it occurs, is expected to proceed at a very slow rate due to the predominantly cohesive bank sediments found in the project reach.

2.6.3. Calera Creek

The majority of the existing creek channel consists of a grassy trapezoidal channel that has been encroached with sediment with approximate 2:1 side slopes and a bottom width of 10 feet. There is moderate vegetation growth of cattail, sedges and wetland type grasses within the low flow channel.

The channel downstream of the drop structure has undergone some vegetation and sediment removal in the past but no regularly scheduled maintenance occurs. The District does no regular maintenance upstream of the drop structure. It does not appear that sedimentation is a significant problem in the project reach as even without scheduled maintenance, the sedimentation rate is minor.

Stream bank erosion is largely absent from the project reach, a condition that is expected to continue into the future. The lack of significant bank erosion is due primarily to the depositional nature of the project reach, channel maintenance activities, and to cohesive bank sediments that are resistant to erosion. Future bank erosion, if it occurs, is expected to proceed at a very slow rate due to the predominantly cohesive bank sediments found in the project reach.

CHAPTER 3. FORMULATION AND EVALUATION OF ALTERNATIVES

CHAPTER 3 FORMULATION AND EVALUATION OF ALTERNATIVES

This chapter describes the range of alternatives considered for the Project and the methodology followed to determine the staff-recommended alternative. For the purpose of development of alternatives and selection of the staff-recommended alternative, the Project is divided into five project elements: Lower Berryessa Creek, Tularcitos Creek, Lower Calera Creek, Upper Calera Creek Element 1 and Upper Calera Creek Element 2.

3.1. Alternatives Approach

Similar approaches were taken to develop alternatives for the Lower Berryessa Creek, Tularcitos Creek and Calera Creek project elements.

For the Lower Berryessa Creek project element, the alternatives development approach was as follows[12]:

1. Identify conceptual alternatives that could meet some or all of the Project objectives (described in Chapter 1), evaluate each conceptual alternative against key Project criteria and qualitatively rate the conceptual alternatives for meeting Project objectives.
2. Gather input from community and City of Milpitas on conceptual alternatives.
3. Screen the conceptual alternatives down to four feasible alternatives for further study.
4. Rate the four feasible alternatives using the District's Natural Flood Protection (NFP) objectives and input from the City of Milpitas.
5. Identify the staff-recommended alternative based on the outcome of the NFP objectives rating and input from the City of Milpitas.

The approach described above was used to develop alternatives for the Tularcitos Creek and Lower Calera Creek project elements, except for the development and screening of conceptual alternatives (steps 1 and 2, above) which were omitted. Omitting these steps had no significant effect on the process or outcome, as the conceptual alternatives identified and evaluated for the Lower Berryessa Creek project element served as a suitable basis for selecting feasible alternatives for further study for Tularcitos Creek and Calera Creek.

[12] Development of alternatives for the Lower Berryessa Creek project element began in 2003, before the District adopted the methodology described in its *Guidance on Alternative Evaluation and Selection for Natural Flood Protection (NFP) Projects*. The initial approach to developing alternatives for Lower Berryessa Creek does not follow the District's NFP methodology. The alternatives development approach for Lower Berryessa Creek was subsequently modified to conform to the NFP methodology. Development of alternatives for Tularcitos Creek and Calera Creek project elements began after the District adopted its NFP methodology and the approach to alternatives development for project elements for these creeks conformed to this methodology from the outset.

The approach for developing alternatives for the Upper Calera Creek Element 1 and Upper Calera Creek Element 2 started with the identification of four feasible alternatives, which were then rated using the NFP objectives and the outcome was used to identify a staff-recommended alternative. This streamlined approach was used because, 1) Calera Creek Element 2 was added to the scope of the Project late in the study timeline; 2) a significant body of work existed from the other project elements on which to identify appropriate feasible alternatives, and; 3) physical constraints limited the number of possible alternatives for this project element.

3.2. Conceptual Alternatives (Lower Berryessa Creek)

The Lower Berryessa Creek project element was studied to define the problems to be addressed by the Project, state the Project objectives and identify conceptual alternatives for meeting the project objectives.[13]

Several problems with existing conditions along the Lower Berryessa Creek project element were identified. These problems are summarized and defined as follows:

- Cracking and slope erosion of expansive soils compromises flood protection by undermining the stability of the existing levees.
- The existing channel cannot contain the design flows that account for future upstream channel improvements.
- Maintenance access roads do not meet District requirements.

Identification and development of conceptual alternatives for the Lower Berryessa Creek project element focused on addressing the following objectives:

> **Flood Protection.** Accommodate the future design flows based on the Upper Berryessa Creek Project and meet District standards for levee freeboard. Any improvements to the levee system must be engineered for satisfactory long-term stability and seepage control.
>
> **Maintenance Access.** The District has a maintenance program that includes removal of debris and trash that collects within the channel. The District also implements a vegetation/sediment removal program that consists of clearing half of the low flow channel of vegetation with some sediment removal each year, with the alternate half undergoing maintenance the subsequent year. These operations require access by District personnel and equipment.
>
> **City of Milpitas Trail System.** The City of Milpitas has two planned trails along the Lower Berryessa Creek project element as part of their trail master plan defined in a Feasibility Report prepared in 1999. The trails are intended to integrate with the natural environment and provide recreation and alternative transportation benefits to businesses,

[13] Winzler & Kelly, *Technical Memorandum, Berryessa Creek Levees Project- Problem Definition, Objectives, and Conceptual Alternatives*, November 7, 2003

schools and neighborhoods. Trail development is also intended to provide an opportunity to enhance the creek corridors as habitat for wildlife and as a scenic open space for trail users.

Habitat Enhancement/Restoration. The project improvements should include habitat enhancement within the project limits beyond what would be affected by the Project. This could include improved riparian and wetlands habitat within the low flow channel as well as improved aesthetics to the levee banks by seeding and/or plantings. This will help reduce the onsite erosion of banks and fit in well with the trail system.

Completion of Construction. The District and Corps are planning flood protection improvements upstream of Calaveras Boulevard. Since the upstream project will result in increased downstream flows, construction of the Lower Berryessa Creek, Tularcitos Creek, and Lower Calera Creek project elements must be completed prior to starting construction of the Upper Berryessa Creek Project.

Various concept alternatives were considered that to a greater or lesser extent met these objectives, some offering a stand-alone solution, while others were intended to be used as building blocks that could be combined to form a variety of integrative solutions addressing the project objectives.

3.3. Conceptual Alternative Development (Lower Berryessa Creek)

A total of 22 conceptual alternatives were developed that could meet some or all of the project objectives. These conceptual alternatives are summarized as follows (see Appendix C for referenced figures[14]):

3.3.1 Managed Floodplain

One alternative was identified that allows many of the natural floodplain processes associated with Berryessa Creek floodplain to occur:

1. Setback Levees (Figure C-2)

This alternative greatly increases the width of the channel and considerably reduces the height of the levees to re-create natural floodplain processes. A channel width of about 250 feet is required to convey the design flows through this broad shallow floodplain. Although little maintenance of the floodplain would be required, maintenance access roads would be provided along each side of the floodplain, requiring a right of way of about 300 feet. All structures and improvements within the floodplain would need to be

[14] Figures provided in appendices are referenced by prefix identifying the appendix in which they are included followed by the figure number from the original source document. For example, Figure A-2 refers to Figure 2 in Appendix A.

acquired by the District and removed. All existing road and railroad bridges would be replaced with longer span structures. The floodplain would be planted with native riparian trees and vegetation. City trails would be integrated into the proposed improvements.

3.3.2. Channel Modifications Within Existing Right Of Way

Five modifications were identified as potential alternatives to provide flood protection without acquisition of additional right of way:

2. Raise Levees (Figure C-3)
The existing levees would be raised to provide protection for peak design flows and widened to meet District maintenance road requirements. Reinforced soils and/or retaining walls would be built within the existing right of way. City trails would be integrated into the improvements. Some road bridges would require retaining walls or replacement.

3. Replace Levees with a Floodwall (Figure C-3)
Floodwalls would be constructed at the top of the existing levees to provide protection for peak design flows and the top of levees would be widened to meet District maintenance road requirements. City trails would be integrated into the improvements. Some road bridges would require retaining walls or replacement.

4. Concrete Channel (Figure C-4)
The existing channel would be reconfigured into a rectangular concrete-lined channel of sufficient dimensions to convey design flows.

5. Replace Railroad Bridge (Figure C-5)
The existing railroad bridges across the creek would be replaced with new structures with soffits above the design water surface. Relatively long approaches on each end of the bridge would be required to keep track grades within allowable limits.

6. Straighten "Double 90" Reach (Figure C-6)
The existing double 90-degree bends in the creek channel near the railroad crossing at Abel Street would be replaced with a longer, smooth "S" curved channel. New railroad crossings would be required for the new channel.

3.3.3. Channel Modifications Outside the Existing Right Of Way

Two channel modifications were identified as potential alternatives to provide flood protection that require acquisition of additional right of way:

7. Widen Channel (Figure C-7)

The existing channel would be widened to convey the design flow by removing the existing levees and constructing new levees of equivalent heights further outboard. The new levees would be wider to meet District maintenance road requirements. City trails would be integrated into the improvements. Additional right of way would be acquired to accommodate the wider channel.

8. Raise Levees (Figure C-7)

The existing levees would be raised to provide protection for peak design flows and would be widened to meet District maintenance road requirements. Acquiring additional right of way would minimize the need for reinforced soils and/or retaining walls. City trails would be integrated with the improvements. Some road bridges may require retaining walls or replacement.

3.3.4. Tributary Modifications

Two tributary modifications were identified as potential alternatives to provide protection against peak design flows:

9. Modify Pump Station (Figure C-8)

The existing City of Milpitas Wrigley-Ford pump station would be modified to change the timing and/or reduce the rate of flows discharged into Berryessa Creek.

10. Construct Tributary Constriction (Figure C-8)

Flow control structures would be constructed to create a flow constriction at the mouths of Calera Creek and/or Tularcitos Creek to reduce peak flows into Berryessa Creek.

3.3.5 Bypass Channel

Two locations for bypass channels were identified that would route flows from the vicinity of the railroad crossing:

11. Upstream of Railroad (Figure C-9)

An inlet structure upstream of the railroad bridges would direct peak flows into a buried bypass conduit that would discharge flows back into Berryessa Creek downstream of the Wrigley-Ford pump station. A new bored pipeline would be required where the conduit passes under the railroads.

12. Downstream of Railroad (Figure C-10)

An inlet structure downstream of the railroad bridges would direct peak flows into a buried bypass conduit that would discharge flows into Berryessa Creek at the confluence with Penitencia Creek.

3.3.6 Detention Basins in Urban Watershed

Using a 100-year 24-hour storm event on the Berryessa Creek watershed, a storage basin of approximately 536 acre-feet would be required to significantly reduce flooding in the existing channel. Seven alternative sites were identified as potential detention facilities within the urban watershed:

13. Wrigley-Ford (Figure C-11)

This site is located along the existing drainage channel upstream of the Wrigley-Ford storm water pump station, paralleling the railroad tracks on the west side of Berryessa Creek. It has a potential for storing approximately 75 acre-feet, or 14 percent of required capacity.

14. Gill Memorial Park (Figure C-11)

This park site is approximately five acres in size, located at the intersection of Paseo Refugio and Santa Rita on the east side of Berryessa Creek. It has the potential for storing approximately 50 acre-feet, or 9 percent of required capacity.

15. Hall Memorial Park (Figure C-11)

This park is approximately 9.5 acres in size located at La Honda and Coyote Streets, west of Berryessa Creek. It is located downstream of the double-90-degree bends at the railroad crossings; thus, it is not particularly well placed. It has the potential for storing approximately 95 acre-feet, or 18 percent of required capacity.

16. Berryessa Creek Park (Figure C-13)

This park is approximately 8 acres in size located at the intersection of Messina and Isadora in the upper urban area of the Berryessa Creek watershed. It has the potential for storing approximately 80 acre-feet, or 15 percent of required capacity.

17. City Center (Figure C-11)

This site is located on the west side of Berryessa Creek just south of Calaveras Boulevard. It is a main shopping center. The parking facilities could be modified to serve as detention storage. It is estimated that the site has the potential for storing approximately 75 acre-feet, or 14 percent of required capacity.

18. Private residences (Figure C-11)

Residential property would be purchased and houses relocated or demolished to construct a detention basin between Abel Street and the Wrigley-Ford channel. An estimated 54 acres would allow storage of the entire estimated 536 acre-feet of runoff.

19. Basins on tributaries (Figure C-13)

Approximately 8 acres would be available for a detention facility on both Tularcitos Creek and Calera Creek, each capable of storing approximately 80 acre-feet, with a combined 30 percent of required capacity.

3.3.7. Detention Basins in Upper Watershed

Three alternative sites were selected as potential detention facilities within the upper watershed of the Project area:

20. Summitpointe Golf Club

This site is located east of Interstate 680 on Country Club Drive at the upper Tularcitos Creek watershed. The site would be graded to capture the full potential volume from this watershed.

21. Ed Levin County Park

This site is located east of Interstate 680 on Calaveras Road in the Arroyo de los Coches watershed. The site would be graded to capture the full potential volume from this watershed.

22. Berryessa Creek Upper Watershed

A 54-acre detention basin would be constructed along the upper reach of Berryessa Creek, in the less-developed land above the urbanized area.

3.4. Conceptual Alternatives Screening Methodology (Lower Berryessa Creek)

Each of the 22 conceptual alternatives and a "no project" alternative were qualitatively evaluated against the following key project criteria:

Flood Protection. Capability to provide flood protection for peak design flows.

Maintenance Access. Capability to provide access for safe and efficient maintenance

Erosion. Potential effects on erosion of channel and existing levees

Sedimentation. Potential effects on deposition or generation of sediment

Local Drainage. Potential effects on local surface and storm drainage systems

Water Quality. Potential effects on water turbidity, temperature and/or pollution

Riparian Vegetation. Potential effects on riparian vegetation in channel

Wetland Potential. Potential effects on wetlands

Wildlife Habitat Potential. Potential effects on wildlife habitat

Fisheries. Potential effects on fish habitat

Aesthetics. Visual quality as viewed from within project boundaries and from adjacent view shed

Recreation. Capability of accommodating public access to trails

Real Estate Acquisition. Extent, difficulty, and cost of acquiring additional right of way

Construction Cost. Low (under $ 10 million), Medium ($10-20 million) or High (over $20 million)

Time to Complete Project. Potential for completing project prior to commencing upstream Corps project.

The results of this evaluation are summarized in a Conceptual Alternatives Matrix, which is included in Appendix C. The matrix reflects information gathered at a Workshop (September 17, 2003) and Public Outreach Meeting (October 29, 2003).

An array of feasible alternatives was developed that considered each of the conceptual alternatives individually and in combination with all other alternatives[15]. This resulted in a total of 105 possible alternatives for analysis (14 independent alternatives plus 91 two-alternative combinations). Using the Conceptual Alternatives Matrix and notes from the District workshop and public meeting as guides, the possible alternatives were grouped into the following four categories:

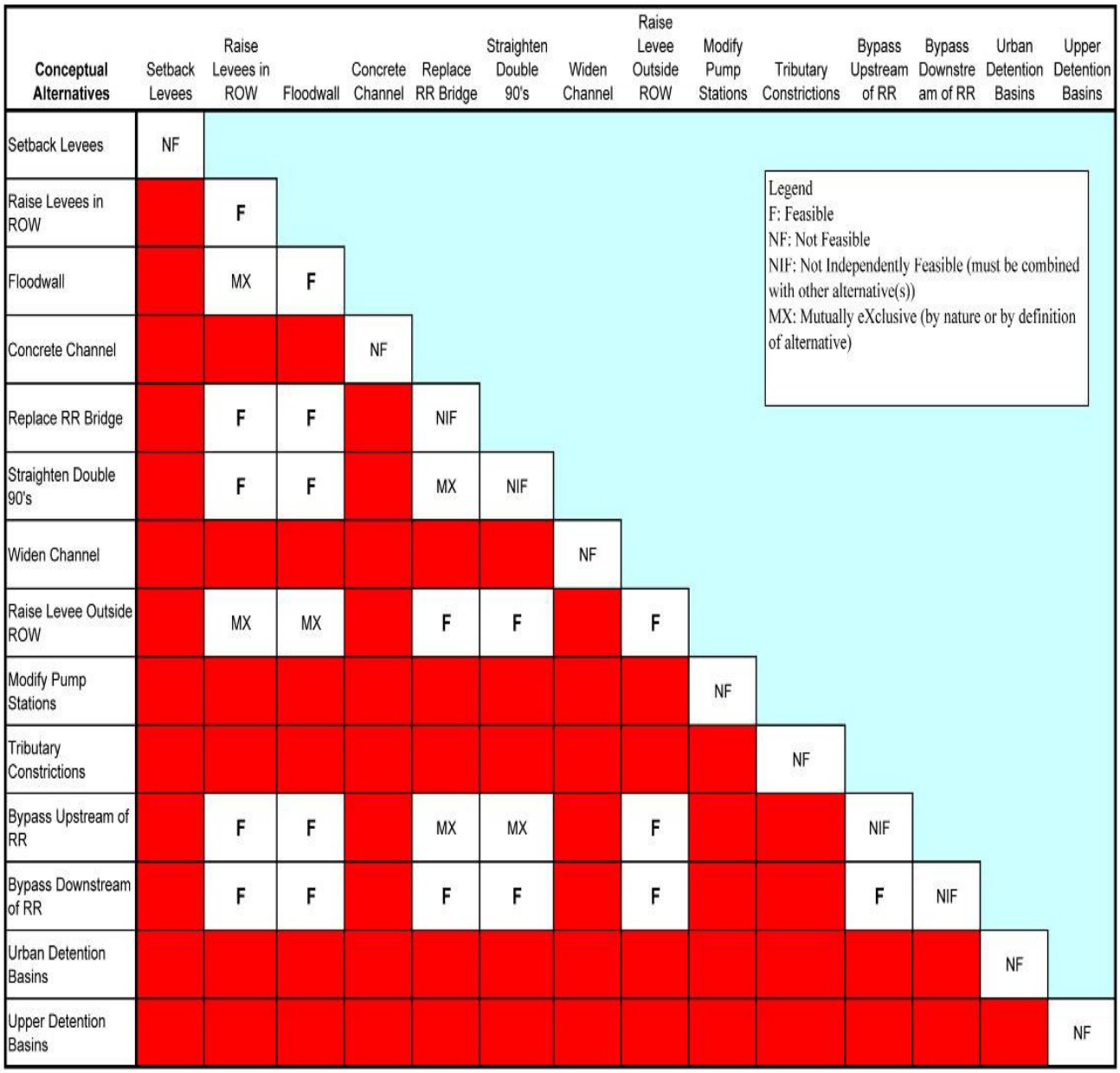
- Feasible- meets project objectives with no "fatal flaws"
- Not Feasible- does not meet project objectives and/or has "fatal flaws"
- Not Independently Feasible- does not meet project objectives by itself, but does in combination with other alternative(s).
- Mutually Exclusive- combination not possible by nature or definition of alternatives.

The results of this analysis are presented in Figure 3-1, Conceptual Alternative Feasibility Matrix. The possible alternatives are listed in the rows and columns of the matrix. The boxes formed by the intersection of the rows and columns of the matrix indicate possible alternatives with independent alternatives appearing along the diagonal of the matrix and combinations occurring everywhere else. Independent alternatives judged Not Feasible resulted in combinations of those alternatives with other alternatives to be considered Not Feasible, and the corresponding boxes in the matrix were blocked out. The code letters in the remaining boxes indicate the category for the remaining possible alternatives.[16]

[15] Winzler & Kelly, *Technical Memorandum, Berryessa Creek Levees Project- Conceptual Alternatives Analysis*, January 26, 2004

[16] Detailed explanation of the evaluation of each of the conceptual alternatives is provided in the above referenced Technical Memorandum. The independent alternatives judged Not Feasible were also not considered feasible in combination with other alternatives due to the severity of their "fatal flaws" or negative impacts.

Figure 3-1: Conceptual Alternative Feasibility Matrix



3.5. Feasible Alternatives - Lower Berryessa Creek

Based on the feasibility assessment of the conceptual alternatives shown in Figure 3-1, 18 alternatives were judged to be feasible (3 independent and 15 combinations of conceptual alternatives). The 18 feasible alternatives are described in the following sections:

3.5.1. Raise Levees in Right of Way (ROW)

The Raised Levees in ROW alternative would require the existing levees be raised to provide protection for peak design flows and the top of the levees widened to meet District maintenance road requirements. Reinforced soils and/or retaining walls would be required to stay within the existing right of way. Some road bridges may require retaining walls or replacement. This alternative would require some modifications to the RR Bridge to allow pressure flow through the structure without overtopping the improved levee system unless combined with other alternatives. Five variations of this alternative were considered feasible:

1. Raise Levees in ROW Only
2. Raise Levees in ROW with Railroad (RR) Bridge Replacement
3. Raise Levees in ROW with Straightened Double 90's
4. Raise Levees in ROW with Bypass Upstream of RR
5. Raise Levees in ROW with Bypass Downstream of RR

3.5.2 Floodwall

The Floodwall alternative would require floodwalls be constructed at the top of the existing levees to provide protection for peak design flows and the top of levees widened to meet District maintenance road requirements. Some road bridges may require retaining walls or replacement. This alternative would require some modifications to the RR Bridge to allow pressure flow through the structure without overtopping the improved levee/floodwall system unless combined with other alternatives. Five variations of this alternative were considered feasible:

6. Floodwalls Only
7. Floodwalls with Railroad (RR) Bridge Replacement
8. Floodwalls with Straighten Double 90's
9. Floodwalls with Bypass Upstream of RR
10. Floodwalls with Bypass Downstream of RR

3.5.3. Raise Levee Outside ROW

The Raise Levee Outside ROW alternative would require the existing levees be raised to provide protection for peak design flows and the top of levees widened to meet District maintenance road requirements. Acquiring additional right of way would reduce the need for reinforced soils and/or retaining walls. Some road bridges may require retaining walls or replacement. This alternative would require some modifications to the RR Bridge to allow pressure flow through

the structure without overtopping the improved levee system unless combined with other alternatives. Five variations of this alternative were considered feasible:

11. Raise Levees Outside ROW Only
12. Raise Levees Outside ROW with Railroad (RR) Bridge Replacement
13. Raise Levees Outside ROW with Straighten Double 90's
14. Raise Levees Outside ROW with Bypass Upstream of RR
15. Raise Levees Outside ROW with Bypass Downstream of RR

3.5.4. Bypass Downstream of RR

The Bypass Downstream of RR alternative would require an inlet structure downstream of the railroad bridges to direct peak flows into a buried bypass conduit that would discharge flows into Berryessa Creek at the confluence with Penitencia Creek. This alternative by itself would not meet the project objectives. It would improve the flooding potential from the confluence of Penitencia Creek upstream to the RR bridges but would not address the severe restriction at the RR bridges. This alternative is feasible only if combined with other alternatives. Three variations of this alternative were considered feasible:

16. Bypass Downstream of RR with RR Bridge Replacement
17. Bypass Downstream of RR with Straighten Double 90's
18. Bypass Downstream of RR with Bypass Upstream of RR

Each of the above feasible alternatives were evaluated against the same 15 project criteria as the original conceptual alternatives. The results of this evaluation are summarized in a Feasible Alternative Matrix which is included in Appendix C. This matrix was used as a guide for screening the 18 feasible alternatives down to six feasible alternatives for further analysis.

3.5.5 Further Analysis of Feasible Alternatives

The 18 feasible alternatives developed and evaluated for the Berryessa Creek project element were discussed in depth at a workshop (December 3, 2003) and were screened down to six feasible alternatives for further analysis based on the 15 project criteria described in Section 3.4.

The six feasible alternatives selected for analysis are identified as:

Alternative 1: Raise levees within existing right of way (ROW) and widen the railroad bridge crossing *(Appendix C, Sheets IR-1 through IR-8)*

Alternative 2: Raise levees within existing ROW and straighten the double 90-degree bends at the railroad crossing *(Appendix C, Sheets IR-1 through IR-8)*

Alternative 3: Raise levees beyond existing ROW and widen the railroad bridge crossing (*Appendix C, Sheets OR-1 through OR-8)*

Alternative 4: Raise levees beyond existing ROW and straighten the double 90-degree bends at the railroad bridge crossing *(Appendix C, Sheets OR-1 through OR-8)*

Alternative 5: Construct levee/wall system within the existing right of way with a riparian vegetation strip adjacent to the levee and straighten the double 90-degree bends at the railroad crossing *(Appendix C, Sheets KC-1 through KC-8)*. This alternative was developed during the December 3, 2003 workshop.

Alternative 6: Managed floodplain *(Appendix C, Sheets GR-1 and GR-2)*. This alternative was introduced to allow many of the natural floodplain processes associated with the natural Berryessa Creek floodplain to occur.

Alternatives 1 through 4 were described in Sections 3.5.1 and 3.5.3.

Alternative 5 would be constructed within the existing right of way and would consist of a raised levee on one side of the channel and a combination of floodwall and access road on the opposite side that would provide high flow capacity. The levee would be constructed with 2:1 side slopes, and an 18-foot wide bench adjacent to the levee would provide a planting strip, to establish permanent riparian vegetation. The wall on the opposite side of the channel would be set in 5 feet from the right of way line to provide a landscaping strip to screen the wall.

Alternative 6 would greatly increase the width of the channel and would considerably reduce the height of the levees to recreate natural floodplain processes. A channel width of about 250 feet would be required to convey the 100-year flows through this broad shallow floodplain. Although little maintenance of the floodplain would be required, maintenance access roads would be provided along each side of the floodplain, requiring a right of way of about 300 feet. All structures and improvements within the floodplain would need to be acquired by the District and removed. All existing road and railroad bridges would be replaced with longer span structures. The floodplain would be planted with native riparian trees and vegetation. City trails would be integrated into the improvements.

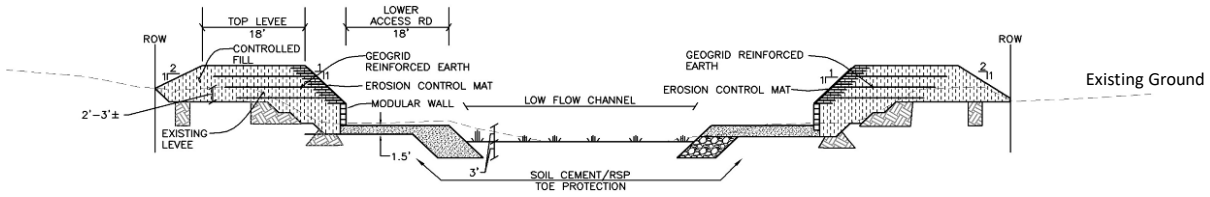
Engineering designs for the six feasible alternatives were developed to the extent necessary to perform hydraulic analyses and prepare preliminary estimates of construction costs.[17] The six feasible alternatives were evaluated using the same 15 project criteria used to evaluate conceptual alternatives, plus an additional criterion, "Construction Impact". The results are summarized in a Feasible Alternative Evaluation Matrix which is included in Appendix C and was used to screen the six feasible alternatives down to four feasible alternatives for final consideration.

[17] Winzler & Kelly, *Technical Memorandum, Berryessa Creek Levees Project-Evaluation of Preliminary Alternatives* , May 20, 2005

Following a workshop (May 17, 2004), staff selected the following four alternatives for final consideration:

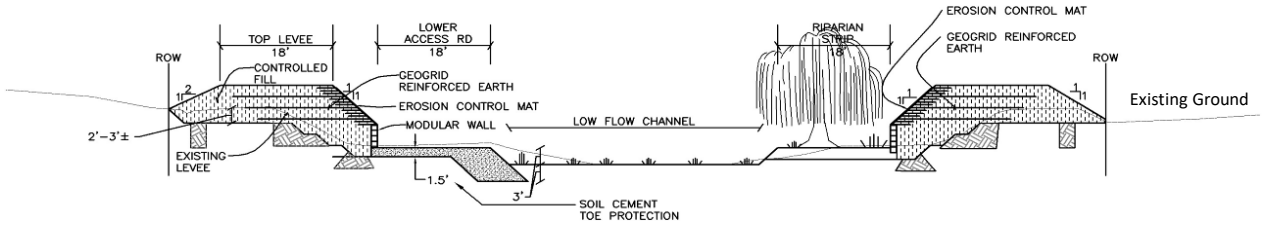
Alternative 1: Raised levees within the existing right of way with two lower maintenance access roads. See Figure 3-2.

Figure 3-2: Lower Berryessa Creek Alternative 1 Typical Section



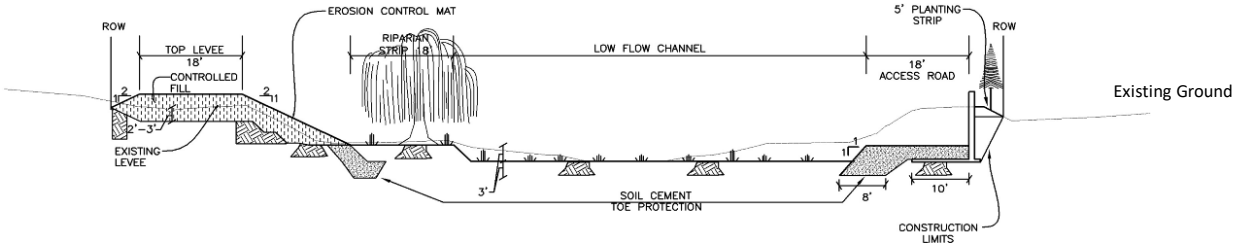
Alternative 2: Raised levees within the existing right of way with a single lower maintenance access road and a riparian vegetation strip in place of one of the access roads of Alternative 1. See Figure 3-3.

Figure 3-3: Lower Berryessa Creek Alternative 2 Typical Section



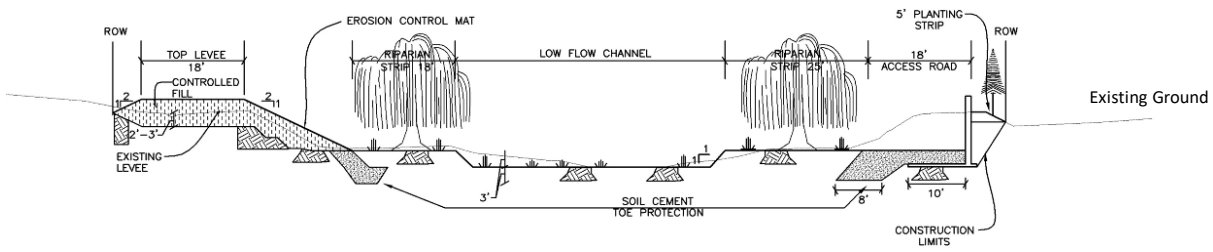
Alternative 3: Levee/wall system within the existing right of way with a riparian vegetation strip similar to Alternative 2. See Figure 3-4.

Figure 3-4: Lower Berryessa Creek Alternative 3 Typical Section



Alternative 4: Levee/wall system within the existing right of way riparian vegetation strips on both sides of the low flow creek channel. See Figure 3-5.

Figure 3-5: Lower Berryessa Creek Alternative 4 Typical Section



Each of the above alternatives also includes improvements where the creek crosses underneath the railroad. These improvements include widening the railroad crossing and straightening the alignment of the creek to eliminate double 90-degree bends. The work required to widen the railroad crossing is being performed by VTA under a cost-sharing agreement with the District.

The results of the study of these four alternatives[18,19] served as the basis of their evaluation and the selection of the staff-recommended alternative for the Lower Berryessa Creek project element.

3.6. Feasible Alternatives – Tularcitos Creek and Calera Creek

The approach used to develop feasible alternatives for Tularcitos Creek and Lower Calera Creek was streamlined, as the conceptual alternatives identified and evaluated for the Lower Berryessa Creek project element served as a suitable basis for identifying 6 feasible alternatives that were further analyzed.

The approach for developing feasible alternatives for the Upper Calera Creek Element 1 and Upper Calera Creek Element 2 started with the identification of 4 feasible alternatives, because the scope of work for these project elements were added late into the planning study timeline and a significant body of work existed from the other project elements on which to identify appropriate feasible alternatives.

3.6.1. Tularcitos Creek

The Tularcitos Creek project element was studied to define project conditions, objectives and present alternatives for flood protection.[20] The existing creek channel is an earthen trapezoidal

[18] Winzler & Kelly, *Technical Memorandum, Lower Berryessa Creed Project-Evaluation of Alternatives*, May 20, 2004

[19] Winzler & Kelly, *Technical Memorandum, Amendment to Lower Berryessa Creek Project-Evaluation of Alternatives*, May 18, 2007.

[20] Winzler & Kelly, *Technical Memorandum- Lower Berryessa Creek Project, Problem Definition, Objectives, and Preliminary Alternatives – Tularcitos Creek Reach*, August 15, 2005.

channel that has been encroached with sediment, with moderate vegetation growth in the low flow channel. Several roads and pedestrian bridges cross the creek. Most of the project element is adjacent to residential neighborhoods and the available right of way is very constrained. A hydraulic model of baseline conditions indicates that the peak design flow cannot be contained within the existing creek channel. This is due to both backwater effects from Berryessa Creek and inadequate channel capacity.

Improvements are required to provide a satisfactory level of flood protection. The objectives of these flood protection improvements are based upon the District Board's Ends Policy (see Section 3.7). The District established relative importance ratings for each of these objectives for the Lower Berryessa Creek Project to serve as a framework for evaluating feasible alternatives.

Six feasible alternatives developed for the Tularcitos Creek project element are:

Alternative 1: Pump Station

Alternative 2: Raise Creek Banks Outside Right Of Way (ROW)

Alternative 3: Raise Creek Banks Within ROW

Alternative 4: Floodwalls

Alternative 5: Sheet Pile Floodwall on One Side of Creek

Alternative 6: Sheet Pile Floodwalls on Both Sides of Creek

The six feasible alternatives were evaluated using the District's Natural Flood Protection (NFP) procedure described in Section 3.7. The evaluation of the 6 feasible alternatives was discussed in a workshop with the City of Milpitas staff (June 25, 2007), which concluded with the selection of the following four feasible alternatives for further study[21]:

Tularcitos Creek Alternative 1: Pump Station. This alternative requires floodwalls on the outside top of access roads bank. Project maintains existing narrow access roads. See Figures 3-6 and 3-7.

[21] Winzler & Kelly, *Technical Memorandum, Lower Berryessa Creek Project, Final Screening of Preliminary Alternatives-Tularcitos Creek Reach*, July 17, 2007

Figure 3-6: Tularcitos Creek Alternative 1 Typical Plan – Pump Station

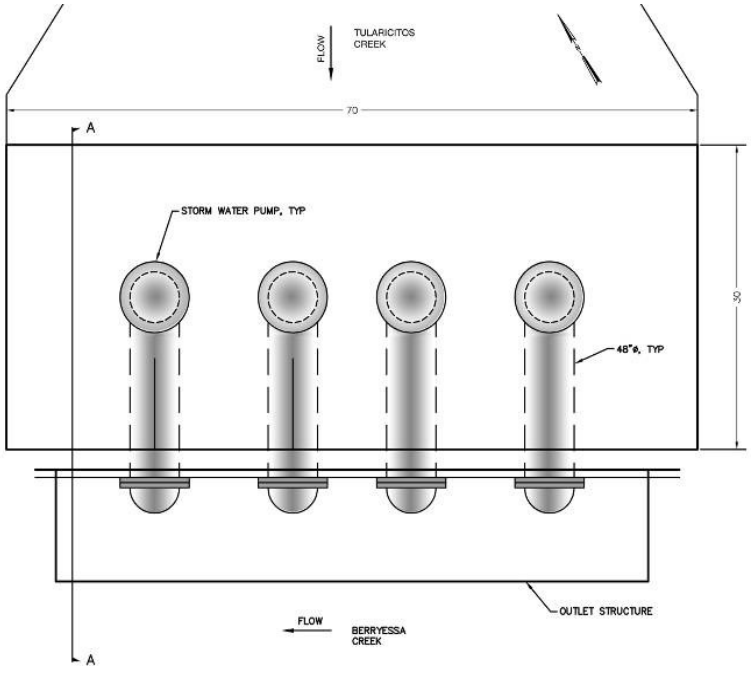
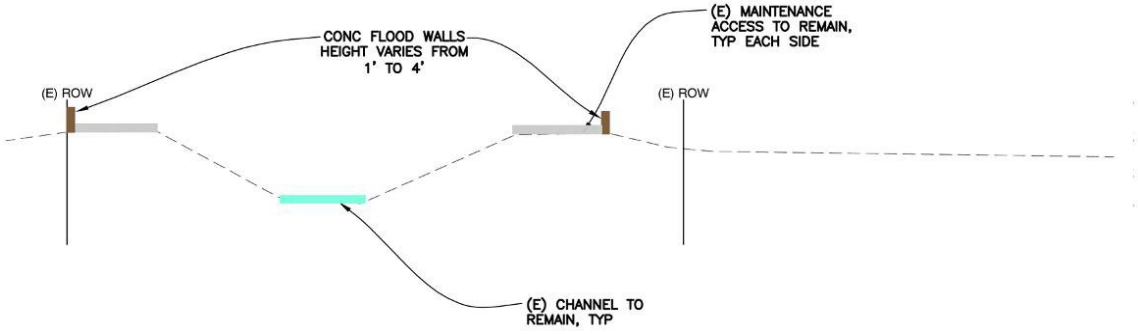
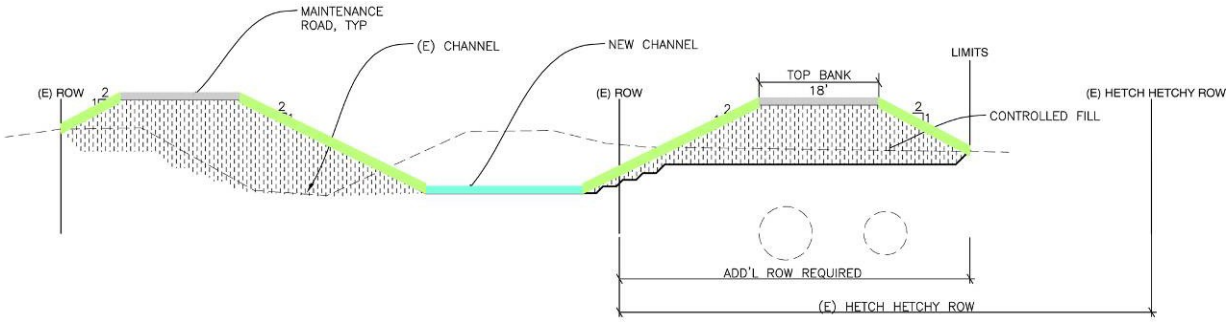


Figure 3-7: Tularcitos Creek Alternative 1 Typical Section – Creek Cross Section



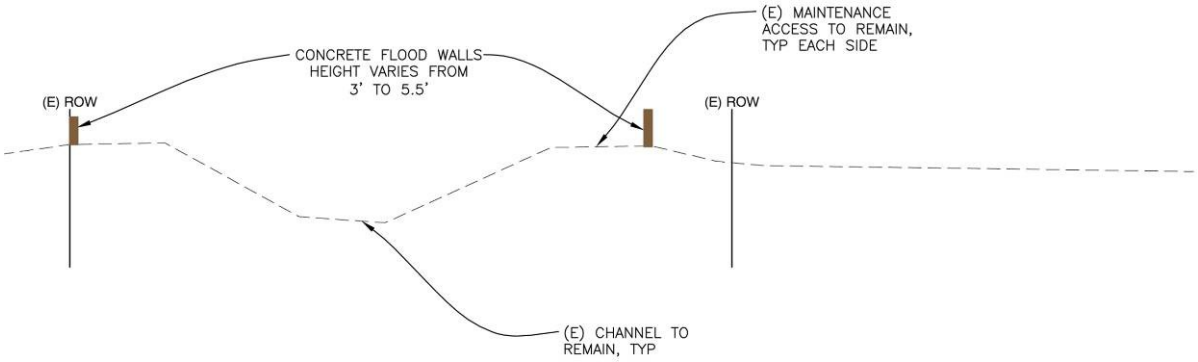
Tularcitos Creek Alternative 2: Raised levees outside the existing right of way. This alternative includes two18 foot access roads on top of bank. See Figure 3-8

Figure 3-8: Tularcitos Creek Alternative 2 Typical Section



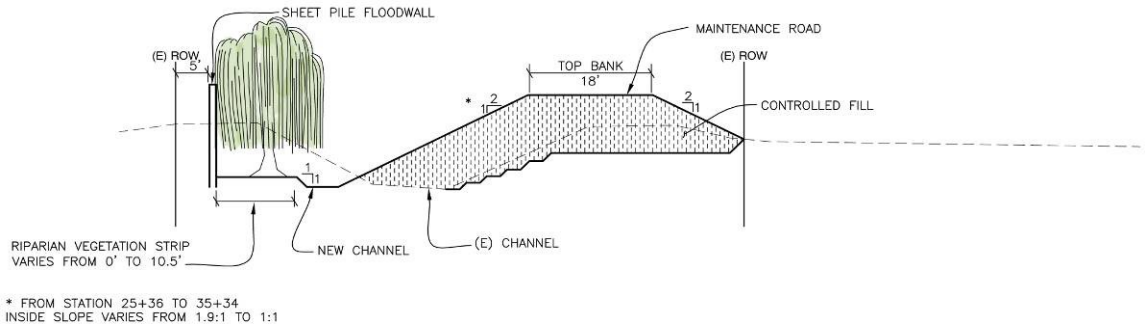
Tularcitos Creek Alternative 3: Floodwalls set along the outside edge of the existing narrow access roads. This alternative maintains existing narrow access roads. See Figure 3-9.

Figure 3-9: Tularcitos Creek Alternative 3 Typical Section



Tularcitos Creek Alternative 4: Levee/Sheet Pile Wall system within the existing right of way with a raised riparian vegetation strip on one side of the low flow creek channel. See Figure 3-10.

Figure 3-10: Tularcitos Creek Alternative 4 Typical Section



The results of the study of these four alternatives[22] served as the basis of their evaluation and the identification of the staff-recommended alternative for the Tularcitos Creek project element.

3.6.2. Lower Calera Creek

The Lower Calera Creek[23] project element was studied to define project conditions, objectives and present alternatives for flood protection.[24] The existing conditions and limitations of this reach of Calera Creek, extending from the confluence with Berryessa Creek to an existing drop structure approximately 3,000 feet upstream are essentially the same as described for Tularcitos Creek.

The criteria and methodology used for Tularcitos Creek was used to develop the following six feasible alternatives for Lower Calera Creek:

Alternative 1: Pump Station

Alternative 2: Raise Creek Banks Outside Right Of Way (ROW)

Alternative 3: Raise Creek Banks Within ROW

Alternative 4: Floodwalls

Alternative 5: Sheet Pile Floodwall on One Side of Creek

[22] Winzler & Kelly, *Technical Memorandum, Lower Berryessa Creed Project, Evaluation of Alternatives-Tularcitos Creek Reach*, July 31, 2007

[23] Upper Calera Element 1 and Element 2 were added to the scope of the Lower Berryessa Creek Project after the study for the downstream reach of Lower Calera Creek was started. The original study documents refer to this downstream reach as the "Calera Creek Reach" without any modifier. Later, this downstream reach was sometimes referred to as the "Lower Calera Creek Reach" to distinguish it from the upstream Upper Calera Creek Reach 1 and Reach 2. The downstream reach is referred to as "Lower Calera Creek" in this report.

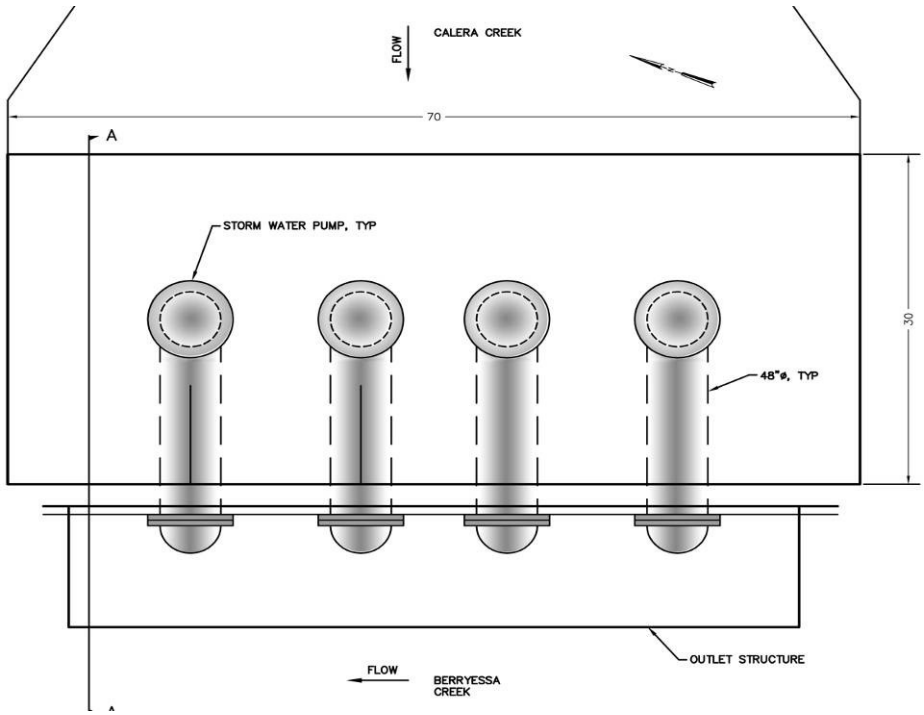
[24] Winzler & Kelly, *Technical Memorandum- Lower Berryessa Creek Project, Problem Definition, Objectives, and Preliminary Alternatives – Calera Creek Reach*, August 24, 2005.

Alternative 6: Sheet Pile Floodwalls on Both Sides of Creek

The six feasible alternatives were evaluated using the District's Natural Flood Protection (NFP) procedure described in Section 3.7. The evaluation was discussed at a workshop with the City of Milpitas staff (June 25, 2007) which concluded with the selection of the following four feasible alternatives for further study[25]:

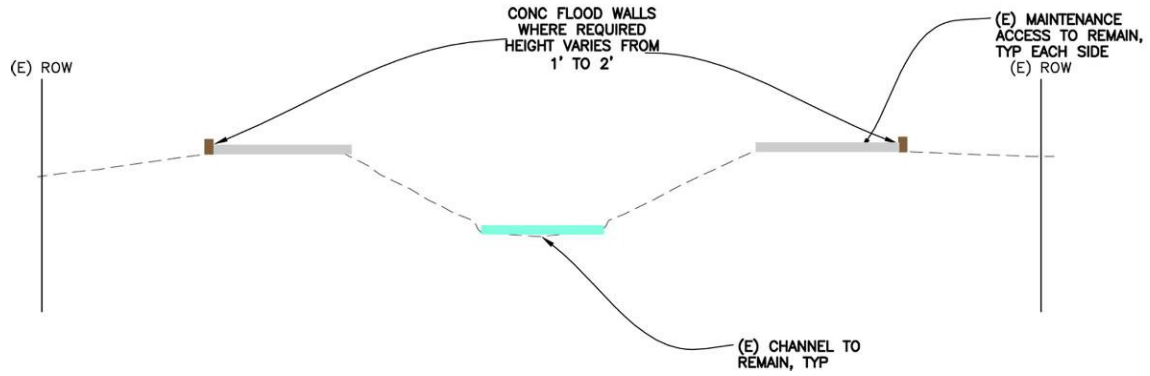
Lower Calera Creek Alternative 1: Pump Station. This alternative requires floodwalls on the outside top of bank of access roads. Project maintains existing narrow access roads. See Figures 3-11 and 3-12.

Figure 3-11: Lower Calera Creek Alternative 1 Typical Plan – Pump Station



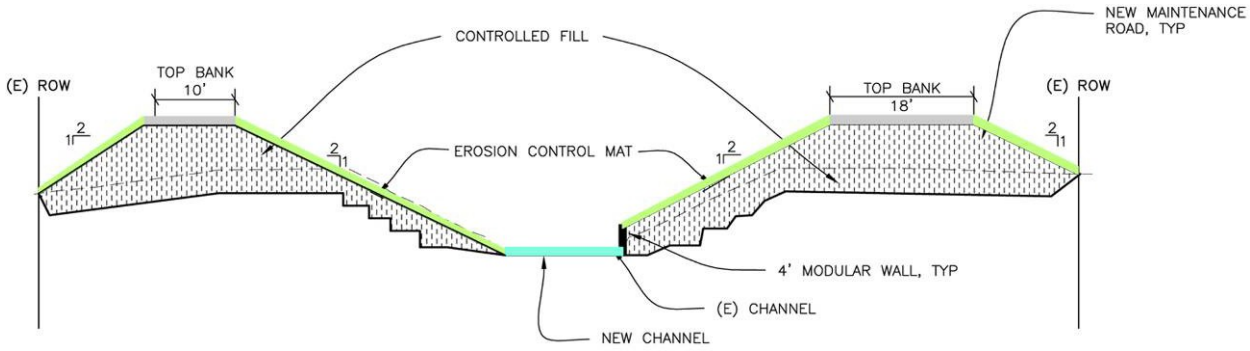
[25] Winzler & Kelly, *Technical Memorandum, Lower Berryessa Creek Project, Final Screening of Preliminary Alternatives-Calera Creek Reach*, July 17, 2007

Figure 3-12: Lower Calera Creek Alternative 1 Typical Section – Creek Cross Section



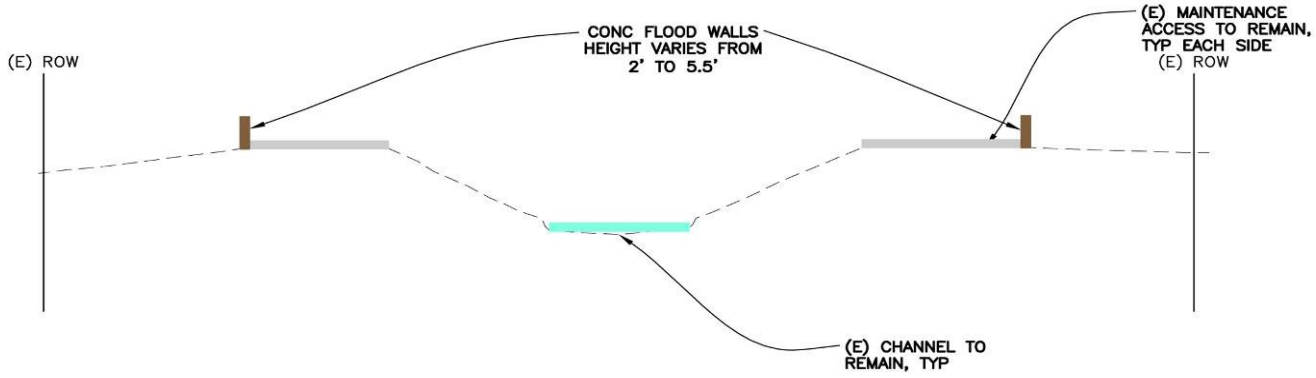
Lower Calera Creek Alternative 2: Raised levees inside the existing right of way. This alternative includes at least one 18 foot access road on top of bank with a second access road varying in width from 10 feet to 18 feet. See Figure 3-13.

Figure 3-13: Lower Calera Creek Alternative 2 Typical Section



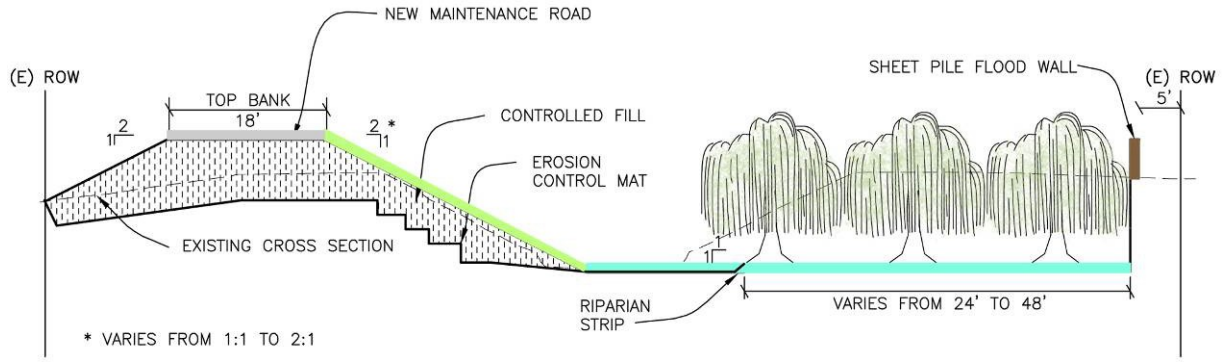
Lower Calera Creek Alternative 3: Floodwalls set along the outside edge of the existing narrow access roads. This alternative maintains existing narrow access roads. See Figure 3-14.

Figure 3-14: Lower Calera Creek Alternative 3 Typical Section



Lower Calera Creek Alternative 4: Levee/Sheet Pile Wall system within the existing right of way with a raised riparian vegetation strip on one side of the low flow creek channel. See Figure 3-15.

Figure 3-15: Lower Calera Creek Alternative 4 Typical Section



The results of the study of these four alternatives[26] served as the basis of their evaluation and the selection of the staff-recommended alternative for the Lower Calera Creek project element.

[26] Winzler & Kelly, *Technical Memorandum, Lower Berryessa Creed Project, Evaluation of Alternatives-Calera Creek Reach*, July 31, 2007

3.6.3. Upper Calera Creek Element 1

Upper Calera Creek Element 1 was studied[27] to develop and evaluate four feasible alternatives, drawing upon the alternatives developed and other work completed for the Lower Berryessa Creek, Tularcitos Creek and Lower Calera Creek project elements, previous studies, and the weighted NFP project objectives. Upper Calera Creek Element 1 extends from just upstream of the existing drop structure to the downstream face of the existing pedestrian bridge near Founders Lane.

A reconnaissance level study performed along Calera Creek from its confluence with Berryessa Creek upstream to Interstate 680 was completed to evaluate channel capacity under the 100-year storm event at existing conditions. Results are presented in the Calera Creek Reconnaissance Study[28] (Reconnaissance Study) and indicate that the channel cannot convey the 100-year flood event and meet freeboard requirements. The floodplain in the upstream reach is more defined than in the downstream reach. Portions of the channel in the upstream reach are described by the Reconnaissance Study as narrow and incised. Backwater effects from Lower Calera Creek do not extend upstream of the existing drop structure separating the downstream backwater from the upstream reach.

The major hydraulic restrictions within Upper Calera Creek Element 1 consist of the drop structure and the culverts under Escuela Parkway. The drop structure forces flow into a narrow cross section, which causes a backwater at the entrance. The second constriction in the culvert crossing at Escuela Parkway, which consists of one, 4-ft by 12-ft box and one, 4-ft by 10-ft box. The culverts reduce the flow area and cause upstream ponding.

In addition to producing a backwater effect that raises the water surface elevation and increases the likelihood of flooding, ponding at the drop structure and at the Escuela Parkway culverts slows down the flow and allows suspended sediment to drop out. As sedimentation builds up in the channel, capacity is reduced and maintenance is required to remove the sedimentation. Sedimentation is reported to occur upstream and downstream of the culverts at Escuela Parkway and upstream of the drop structure.

Due to the proximity of two Hetch Hetchy water mains to the culverts under Escuela Parkway, replacement of the culverts was not considered.

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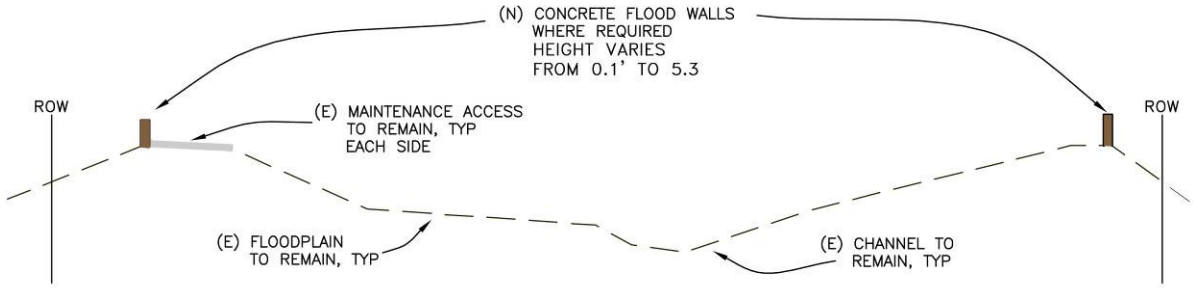
[27] Winzler & Kelly, *Draft Technical Memorandum, Lower Berryessa Creek Project, Evaluation of Alternatives-Upper Calera Creek Reach*, October 23, 2007.

[28] Santa Clara Water Valley District Coyote Watershed Program, *Calera Creek Reconnaissance Study, Final Report,* April 2004

In order to address channel capacity problems and hydraulic limitations imposed by the existing drop structure and existing culverts at Escuela Parkway, the following four alternatives for Upper Calera Creek Element 1 project element were selected for study and evaluation:

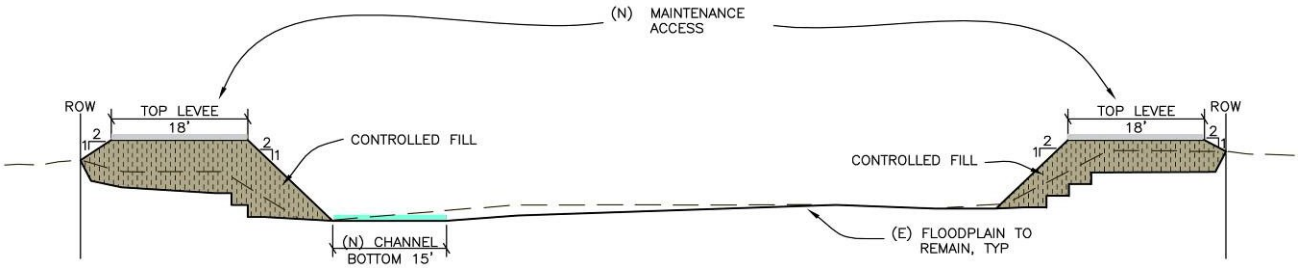
Upper Calera Creek Element 1, Alternative 1: Floodwalls constructed on the top of bank outside of existing access roads will provide required freeboard for design flows. Existing narrow access roads are retained. See Figure 3-16.

Figure 3-16: Upper Calera Creek Element 1, Alternative 1 Typical Section



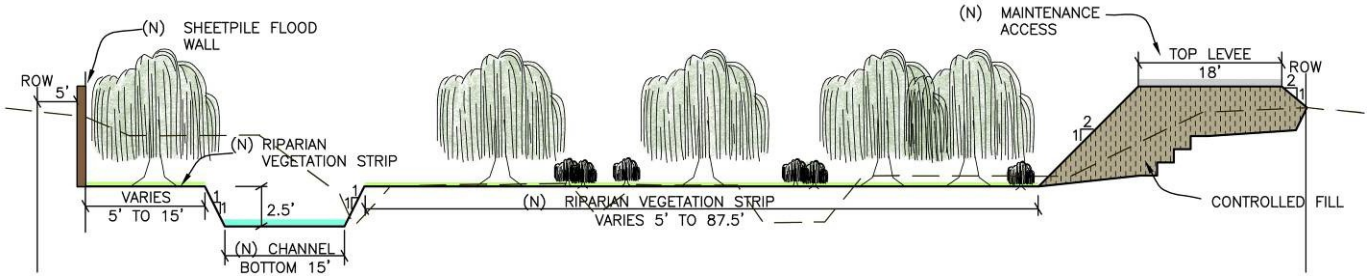
Upper Calera Creek Element 1, Alternative 2: Raised levees inside the existing right of way. This alternative includes two 18 foot wide access roads on top of a constructed bank. See Figure 3-17.

Figure 3-17: Upper Calera Creek Element 1, Alternative 2 Typical Section



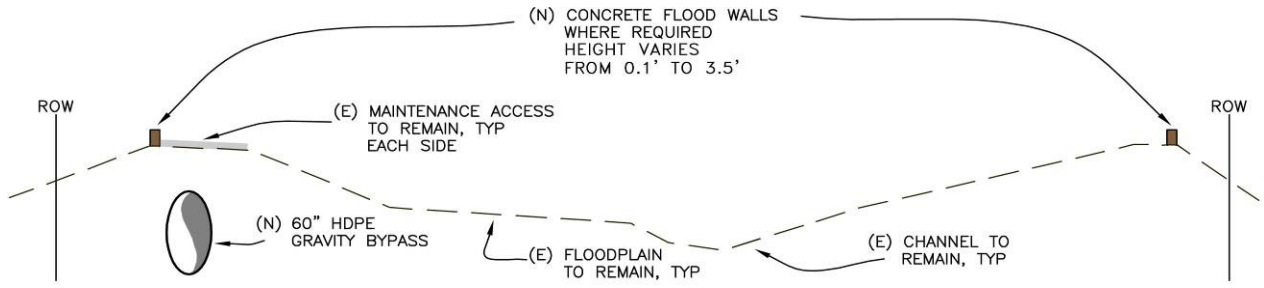
Upper Calera Creek Element 1, Alternative 3: Levee/Sheet Pile Wall system, with drop structure removal. This alternative includes removal of the existing drop structure and regrading of the channel from the downstream end of the structure to the downstream end of the Escuela Parkway culverts. An 18 foot wide levee on the right overbank provides freeboard and access for maintenance. A sheet pile wall along the left overbank increases channel capacity and provides freeboard. A raised, vegetative strip is included in the design. See Figure 3-18.

Figure 3-18: Upper Calera Creek Element 1, Alternative 3 Typical Section



Upper Calera Creek Element 1, Alternative 4: A high density polyethylene (HDPE) gravity pipe bypass diverts up to 200 cfs of flow from the channel. New floodwall provides freeboard where required. See Figure 3-19.

Figure 3-19: Upper Calera Creek Element 1, Alternative 4 Typical Section



The results of the study of these four alternatives served as the basis of their evaluation and the identification of the staff-recommended alternative for Upper Calera Creek Element 1. The results of evaluation of the feasible alternatives are presented in Table 3-5.

3.6.4. Upper Calera Creek Element 2

Four flood protection alternatives for Upper Calera Creek Element 2 were developed and evaluation[29]. The Upper Calera Creek Element 2 extends from the upper limits of the Upper Calera 1 project element upstream approximately 3,000 feet.

The evaluation of alternatives for Upper Calera Creek Element 2 begins at the existing pedestrian bridge at the upper limits of the Upper Calera Creek Element 1 project element and extends upstream, crossing I-680 and North Park Victoria Drive, through Jose Hugera Adobe Park and into private property to the north, a distance of approximately 3,000 feet.

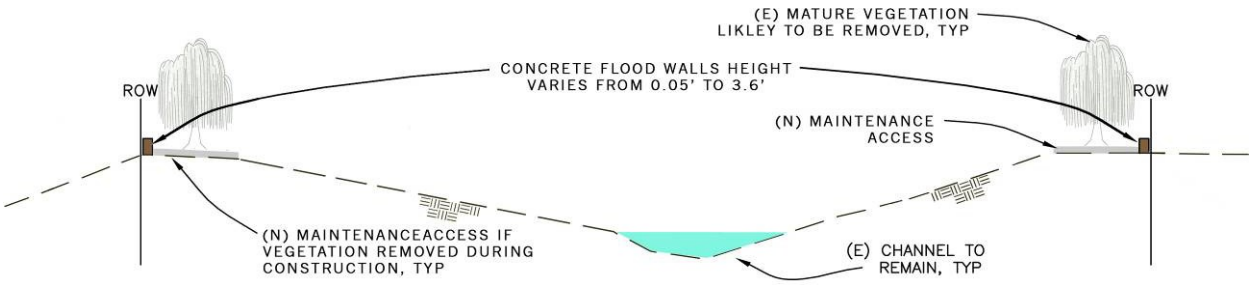
Upstream of the pedestrian bridge at the upper limit of Upper Calera Creek Element 1, the ROW for Calera Creek Element 2 becomes significantly restricted to only about 60 feet wide. The channel upstream of I-680 is not located in District ROW. The District has access ROW adjacent to the west side of the channel, but the channel itself is within the City park property and on private property.

In order to address channel capacity problems and hydraulic limitations imposed by the limited channel section and ROW, the following four alternatives for Upper Calera Creek Element 2 were selected for study and evaluation:

Upper Calera Creek Element 2, Alternative 1: Floodwalls constructed on the top of bank at ROW line outside of potential access roads currently overgrown with mature trees will provide required freeboard for design flows. Narrow access roads are added. See Figure 3-20.

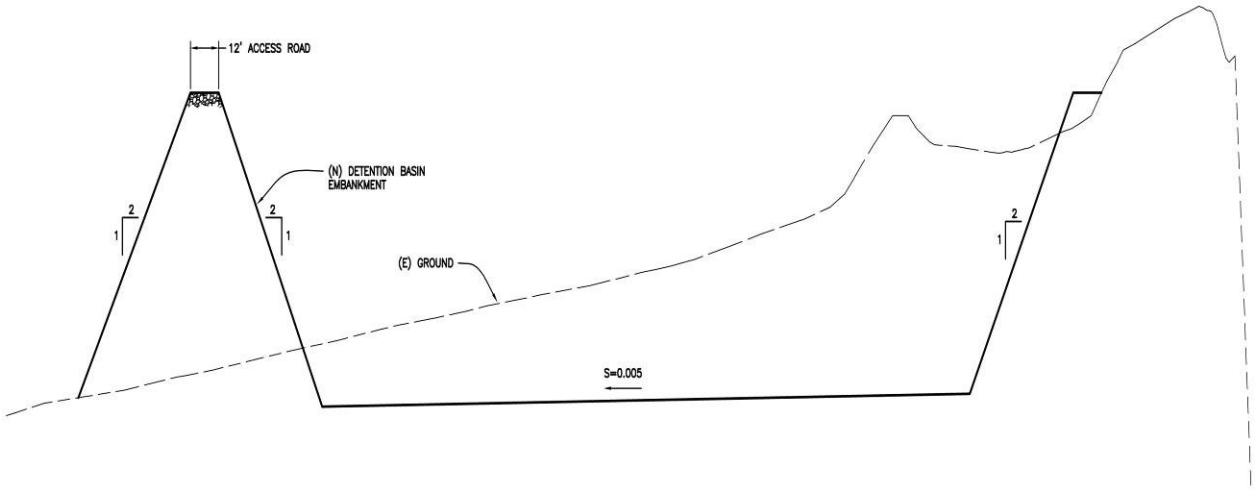
[29] Winzler & Kelly, *Draft Technical Memorandum, Lower Berryessa Creek Project, Evaluation of Alternatives-Upper Calera Creek Reach 2*, November 12, 1008

Figure 3-20: Upper Calera Creek Element 2, Alternative 1 Typical Section



Upper Calera Creek Element 2, Alternative 2: Two detention basins upstream of Caltrans Highway 680 (I-680) will reduce peak flows to within the conveyance capacity of the existing channel. See Figure 3-21.

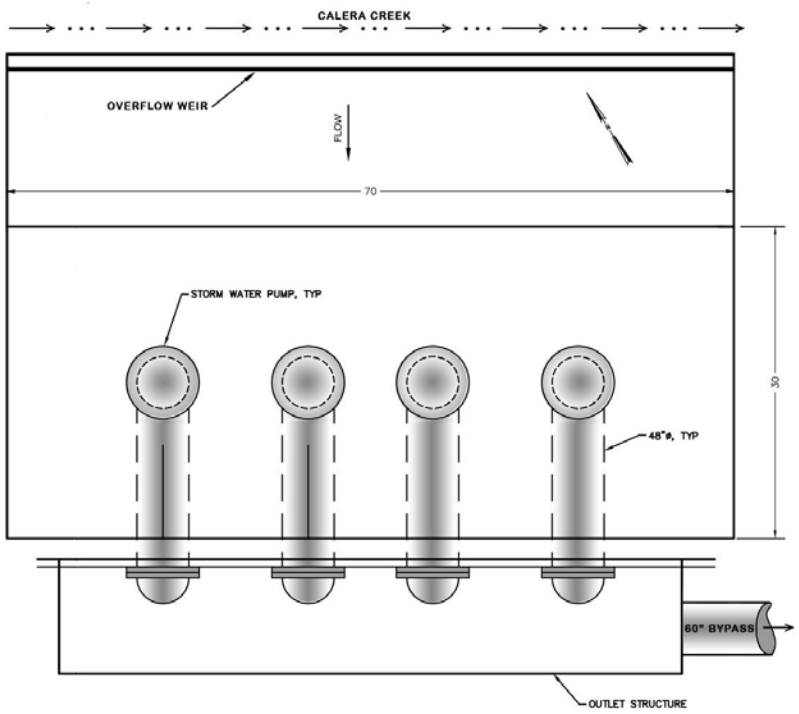
Figure 3-21: Upper Calera Creek Element 2, Detention Basin Typical Section



Upper Calera Creek Element 2, Alternative 3: Pump Station in creek channel downstream of I-680 diverts up to 370 cfs from just downstream of I-680 through a 60 inch diameter force main on the east side of the channel that continues along the same alignment as the Alternative 4 -

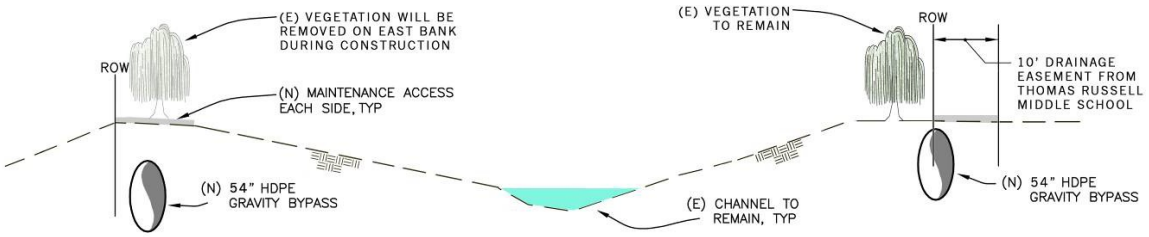
Gravity Bypass in Upper Calera Creek Element 1, discharging below the drop structure. See Figure 3-22.

Figure 3-22: Upper Calera Creek Element 2, Alternative Typical Plan – Pump Station



Upper Calera Creek Element 2, Alternative 4: A high density polyethylene (HDPE) 54-inch gravity pipe bypass on the east side of the channel diverts up to 200 cfs of flow from downstream of I-680 and ties to the gravity bypass of Alternative 4 for Upper Calera Creek Element 1. A second 54 inch gravity main on the west side of the channel diverts up to 170 cfs from just downstream of I-680, and discharges at the upstream limits of Upper Calera Creek Element 1. See Figure 3-23.

Figure 3-23: Upper Calera Creek Element 2, Alternative 4 Typical Section



The results of the study of these four alternatives served as the basis of their evaluation and the identification of the staff-recommended alternative for Upper Calera Creek Element 2. The results of the evaluation of the feasible alternatives are presented in Table 3-6.

3.7. Feasible Alternatives Ranking Methodology

The feasible alternatives ranking methodology for the Lower Berryessa Creek Project is based upon the District's Guidance on Alternative Evaluation and Selection for Natural Flood Protection (NFP) Projects[30].

The methodology is based upon the District Policy for reduced potential for flood damages. District policy provides the basis for multiple objectives that result in "natural flood protection that balances environmental quality, community benefit, and protection from creek flooding in a cost effective manner." The District's policy identifies the following nine objectives that serve as a framework for evaluating project alternatives:

1. **Flood Protection:** Homes, schools, businesses, and transportation networks are protected from flooding and erosion.
2. **Ecology:** Ecological functions and processes are supported.
3. **Geomorphology/Stable Channel:** Physical stream functions and processes are integrated.
4. **Maintenance:** Maintenance requirements are minimized
5. **Watershed Context:** Projects are integrated within the watershed as a whole.
6. **Water Quality/Quantity:** The quality and availability of water is protected.

[30] Santa Clara Valley Water District, *Guidance on Alternative Evaluation and Selection for Natural Flood Protection Projects,* Revision 1 August 2005.

7. **Local Partner Agencies:** Cooperation with local agencies achieves mutually beneficial goals.

8. **Community Benefits:** Community benefits beyond flood protection

9. **Life Cycle Costs:** Life-cycle costs are minimized

The District's CEO interpretation of "natural flood protection" is: "A multiple-objective approach to providing environmental quality, community benefit and protection from creek flooding in a cost effective manner through planning and management that considers the physical, hydrologic and ecologic functions and processes of streams within the community setting."

The policy to balance the nine objectives listed above does not indicate a priority ranking of objectives; therefore, overall weighting of these objectives was determined on a project-specific basis. District staff and community stakeholders, established the relative weightings of objectives for the Lower Berryessa Creek Project[31]. These weightings are summarized in the following table:

Table 3-1: NFP Objectives and Relative Weightings

No.	NFP Objective	Relative Weight
1	Flood Protection	10
2	Ecology	6
3	Geomorphology/Stable Channel	10
4	Maintenance	10
5	Watershed Context	5
6	Water Quality/Quantity	6
7	Local Partner Agencies	10
8	Community Benefits	7
9	Life Cycle Costs	7

[31] SCVWD (Marc Klemencic), *Matrix- Lower Berryessa Creek Flood Protection Project, Nine NFP Objectives (With Relative Importance Ratings),* May 4, 2005

Each of the project alternatives developed were evaluated against these weighted objectives using the District's NFP procedure.

3.7.1. Summary of NFP Procedure

As required by the Ends Policy, the procedure balances the nine NFP objectives. Various criteria (as few as one to as many as seven) help rate each objective. These criteria are:

Objective 1: Provide protection from flood damage

- Criterion 1: safety – protection of public safety if conditions exceed design assumptions
- Criterion 2: economic protection – protection from damage due to floodwaters, erosion or sediment
- Criterion 3: durability – future effort required to maintain design level of protection
- Criterion 4: resiliency – adaptability to future changes
- Criterion 5: local drainage – support of local storm drain systems
- Criterion 6: time to implementation – how quickly flood protection elements could become effective

Objective 2: Support ecological functions and processes

- Criterion 1: local habitat goals – ability to meet habitat goals as defined from examining the watershed as a whole
- Criterion 2: habitat provided – quality of habitat provided by alternative
- Criterion 3: sustainability of habitat – intensity of future action required to maintain design habitat quality
- Criterion 4: connectivity of habitat – integration of habitat elements into surrounding landscape

Objective 3: Physical stream functions and processes

- Criterion 1: Floodplain – inclusion of appropriately sized floodplain
- Criterion 2: Active channel – appropriateness of size and configuration of active channel
- Criterion 3: Stable side slopes – stability of side slopes
- Criterion 4: Transitions – stability of channel's integration with upstream and downstream reaches

Objective 4: Minimize maintenance requirements

- Criterion 1: structural features – maintenance associated with structural features
- Criterion 2: natural processes – maintenance associated with vegetation, erosion and sediment
- Criterion 3: urban flows – maintenance resulting from small storms and outfall flows
- Criterion 4: access – incorporation of adequate access for maintenance crews and equipment

Objective 5: integrate within watershed

- Criterion 1: meets watershed goals – ability to meet watershed goals as defined in a process that examines the watershed as a whole

Objective 6: Protect the quality and availability of water

- Criterion 1: Water availability – impact on groundwater recharge
- Criterion 2: Instream water quality – water quality protected through vegetation and instream hydraulic complexity
- Criterion 3: Offstream water management – ability to enhance water supply and quality and reduce peak flows through local retention of rainfall
- Criterion 4: Flow regime – ability to maintain geomorphically and biologically appropriate range of flows

Objective 7: Cooperate with other local agencies to achieve mutually beneficial goals

- Criterion 1: mutual local goals – ability to achieve project-specific goals and objectives developed jointly by the District and local agencies
- Criterion 2: supports general plan – ability to support goals and policies as stated in general plans of partner agencies

Objective 8: Community benefits beyond flood protection

- Criterion 1: community safety – overall safety for appropriate access and recreation
- Criterion 2: recreation – quality of recreation experience provided by alternative
- Criterion 3: aesthetics – quality of aesthetic form provided by alternative
- Criterion 4: social and cultural benefits – opportunity to provide community involvement
- Criterion 5: local economic effects – potential effect on property values and/or local business climate
- Criterion 6: open space – inclusion of open space into alternative
- Criterion 7: community support – alternative reflects community developed objectives and ideas

Objective 9: Minimize life-cycle costs

- Criterion 1: net present value of lifetime costs

Some of the criteria require comparative ratings between the alternatives (for example, which alternative has the least or the most cost) while others require stand-alone ratings (for example, how well the alternative meets community goals). Each alternative was rated as to how well it accomplished each criterion. Rating matrices were prepared for each objective and a scoring system assigned various weights to the criteria and calculated the objective score (see Appendix C for NFP rating details) for each alternative.

The result is an Alternatives Comparison Matrix which presents a comparison of how well the alternatives rated on each of the nine NFP objectives. The Alternatives Comparison Matrix for each project element are presented in Tables 3-2 through 3- 6.

Table 3-2: Feasible Alternatives Comparison Matrix – Lower Berryessa Creek

Outstanding | Very Good | Adequate | Fair | Poor | Unacceptable

Alternative	Objective								
	Protection from Flood Damage (10)	Ecological Functions (6)	Channel Functions (10)	Maintenance (10)	Integrated with Watershed (5)	Water Quality & Availability (6)	Other Agency Support (10)	Community Benefits (7)	Life-Cycle Costs (7)
1 - Raised Levees ≤ Row	Adequate	Poor	Poor	Fair	*	Fair	*	Adequate	Adequate
2 - Raised Levees ≤ Row w/ Riparian Strip	Adequate	Fair	Poor	Fair	*	Adequate	*	Adequate	Fair
3 - Levee/ Wall System w/ Riparian Strip	Adequate	Fair	Fair	Fair	*	Adequate	*	Adequate	Adequate
4 - Levee/Wall System w/ two Riparian Strips	Adequate	Adequate	Fair	Fair	*	Adequate	*	Adequate	Fair

* Input not received for these criteria

Alternatives rated best for each objective

Table 3-3: Feasible Alternatives Comparison Matrix – Tularcitos Creek

Outstanding | Very Good | Adequate | Fair | Poor | Unacceptable

Alternative (Relative Weight)	Objective								
	Protection from Flood Damage (10)	Ecological Functions (6)	Channel Functions (10)	Maintenance (10)	Integrated with Water-shed (5)	Water Quality & Availability (6)	Other Agency Support (10)	Community Benefits (7)	Life-Cycle Costs (7)
1 - Pump Station	Adequate	Fair	Poor	Poor	*	Adequate	*	Adequate	Fair
2 - Raise Banks ≤ Row	Adequate	Fair	Poor	Fair	*	Adequate	*	Adequate	Very Good
3 - Flood Wall	Fair	Fair	Poor	Poor	*	Adequate	*	Adequate	Very Good
4 - S P Flood Wall 1-Side	Fair	Very Good	Fair	Fair	*	Very Good	*	Adequate	Fair

* Input not received for these criteria

Alternatives rated best for each objective

Table 3-4: Feasible Alternatives Comparison Matrix – Lower Calera Creek

Outstanding | Very Good | Adequate | Fair | Poor | Unacceptable

Alternative (Relative Weight)	Objective								
	Protection from Flood Damage (10)	Ecological Functions (6)	Channel Functions (10)	Maintenance (10)	Integrated with Water-shed (5)	Water Quality & Availability (6)	Other Agency Support (10)	Community Benefits (7)	Life-Cycle Costs (7)
1 - Pump Station					*		*		
2 - Raise Banks ≤ Row					*		*		
3 - Flood Wall					*		*		
4 - S P Flood Wall 1-Side					*		*		

* Input not received for these criteria

Alternatives rated best for each objective

Table 3-5: Feasible Alternatives Comparison Matrix – Upper Calera Creek Element 1

Outstanding | Very Good | Adequate | Fair | Poor | Unacceptable

Alternative (Relative Weight)	Objective								
	Protection from Flood Damage (10)	Ecological Functions (6)	Channel Functions (10)	Maintenance (10)	Integrated with Water-shed (5)	Water Quality & Availability (6)	Other Agency Support (10)	Community Benefits (7)	Life-Cycle Costs (7)
1 - Flood Wall					*		*		
2 - Raise Banks ≤ Row					*		*		
3 - Levee/Sheet Pile Wall					*		*		
4 - Gravity By Pass					*		*		

* Input not received for these criteria

Alternatives rated best for each objective

Table 3-6: Feasible Alternatives Comparison Matrix – Upper Calera Creek Element 2

Outstanding | Very Good | Adequate | Fair | Poor | Unacceptable

Alternative (Relative Weight)	Objective								
	Protection from Flood Damage (10)	Ecological Functions (6)	Channel Functions (10)	Maintenance (10)	Integrated with Water-shed (5)	Water Quality & Availability (6)	Other Agency Support (10)	Community Benefits (7)	Life-Cycle Costs (7)
1 - Flood Wall	Adequate	Fair	X	Poor	*	Adequate	*	Fair	Adequate
2 - Detention Basin	Adequate	Adequate	X	Fair	*	Very Good	*	Fair	Fair
3 - Pump Station	Adequate	Adequate	X	Poor	*	Fair	*	Fair	Poor
4 - Gravity By Pass	Adequate	Adequate	X	Poor	*	Fair	*	Fair	Fair

* Input not received for these criteria

Alternatives rated best for each objective

3.8. Identification of Staff-Recommended Alternative

A staff-recommended alternative was selected for each project element based on comparison of the NFP ratings for all of the alternatives developed for that element and as a result of discussions and meetings with the District staff and the City of Milpitas.

3.8.1. Lower Berryessa Creek

Alternative 3, "Levee/Wall System with Riparian Strip" was selected as the staff-recommended alternative for the Lower Berryessa Creek project element. This alternative tied with Alternative 4, "Levee/Wall System with Two Riparian Strips" for the top overall rating of the four alternatives. Alternatives 3 and 4 both have riparian plantings that contribute significantly to supporting ecological and channel functions and processes. The floodwall in both alternatives reduces ongoing and post-flood maintenance costs. Alternative 3 was favored over Alternative 4 primarily because Alternative 3 has the lowest design water surface elevation, which reduces the backwater effects on the Tularcitos Creek and Calera Creek tributaries, thus reducing the extent of flood protection improvements required along these tributaries.

Alternative 2, "Raised Levees in ROW with Riparian Strip" was not selected primarily because it results in the highest design water surface elevation. Alternative 1, "Raise Levees in ROW" does not provide the beneficial effects of the riparian plantings.

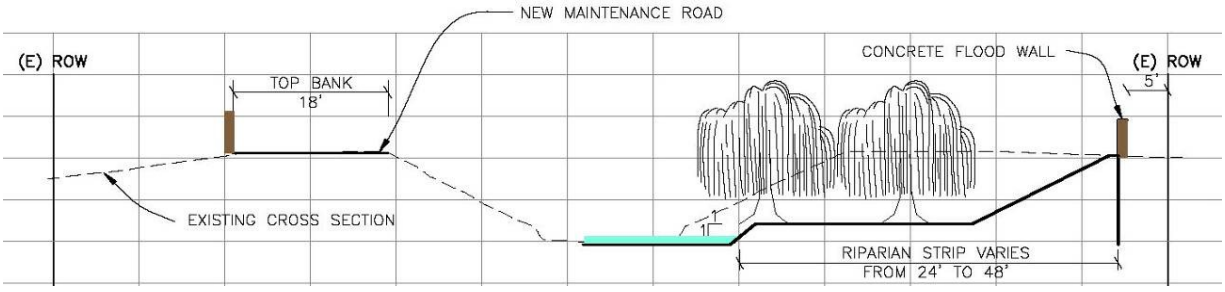
3.8.2. Tularcitos Creek

Alternative 1, "Pump Station" is the staff-recommended alternative for the Tularcitos Creek project element. Although Alternative 1 received the lowest NFP rating, it was identified after extensive discussions with the City of Milpitas, due to the community benefits it would preserve. Currently, Tularcitos Creek is a visible and accessible asset to nearby residents. Paths and pedestrian bridges provide connectivity between neighborhoods. The other three alternatives considered would block views to and across the creek and significantly reduce access and connectively. These alternatives would result in an unacceptable loss of neighborhood connectivity. Alternative 1 addresses the backwater effects at the confluence with Berryessa Creek directly and minimizes the extent of upstream improvements along Tularcitos Creek.

3.8.3. Lower Calera Creek

A combination of Alternative 1, "Floodwall" and Alternative 4, "Levee/Sheet Pile Wall" was identified as the staff-recommended alternative for the Lower Calera Creek project element. This alternative consists of concrete floodwalls on each bank, a maintenance road along one bank and a benched riparian strip adjacent to the low flow channel. See Figure 3-24. This achieves the cost advantages of Alternative 1 floodwalls and the ecological, channel function, water quality, and community benefits of Alternative 4.

Figure 3-24: Lower Calera Creek - Typical Channel Section



3.8.4. Upper Calera Creek Element 1

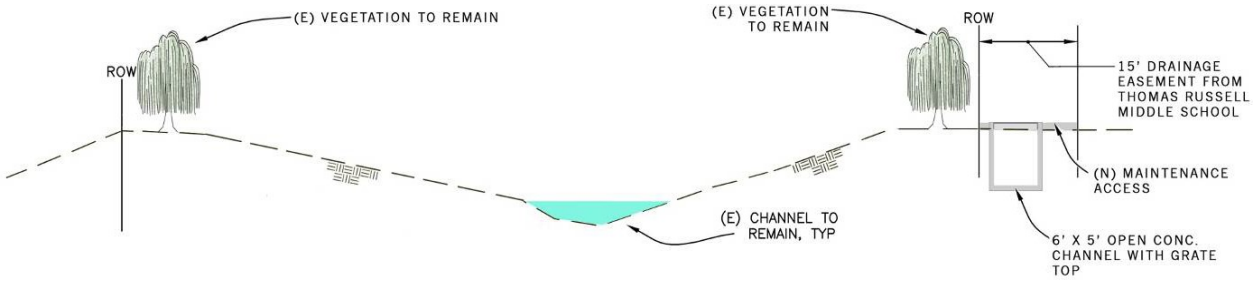
Alternative 1, "Floodwall" was identified as the staff-recommended alternative for Upper Calera Creek Element 1, in consultation with the City of Milpitas. The ratings for all four alternatives are quite close, but Alternative 1 was determined by District staff and City of Milpitas representatives to be the least costly and least disruptive to existing vegetation.

3.8.5. Upper Calera Creek Element 2

Downstream of I-680, a modified version of Alternative 4, "Gravity Bypass" was developed for Upper Calera Element 2. This modified alternative consists of a single concrete open box bypass channel located on one side of the creek outside of the District's ROW, on property owned by Milpitas Unified School District (Figure 3-25). This alternative has the least impact on existing mature trees adjacent to the creek and is less disruptive to construct compared to the other alternatives and the original Alternative 4.

Upstream of I-680, proposed improvements consist of modifying an existing drop structure and reconstructing approximately 200 feet of channel. These proposed improvements are common to all the alternatives considered for this project element.

Figure 3-25: Upper Calera Creek Element 2 - Gravity Bypass



CHAPTER 4. STAFF-RECOMMENDED ALTERNATIVE

CHAPTER 4 STAFF-RECOMMENDED ALTERNATIVE

The design criteria, proposed project elements and construction procedures for the staff-recommended alternative are described in this chapter. See Appendix D (bound separately) for the concept drawings of the staff-recommended alternative. A description of the maintenance guidelines for the staff-recommended alternative is provided in Chapter 5.

4.1 Design Criteria

The design criteria for the staff-recommended alternative include criteria that are common to all of the Lower Berryessa Creek, Tularcitos Creek and Calera Creek project elements and criteria that are specific to each element. The following design criteria are common to all project elements:

- Provide flood protection for the peak design flows
- Improve access for long-term channel maintenance
- Incorporate opportunities to integrate levees with the City of Milpitas trail system[32]
- Identify opportunities for stream habitat enhancement and/or restoration
- Improvements are to remain inside District's existing right of way wherever feasible.

In order to provide flood protection for peak design flows, District requirements for minimum freeboard must be satisfied. These freeboard requirements are:

- Provide a minimum of 3 feet of freeboard at all locations and a minimum of 4 feet of freeboard from the upstream face of bridge structures for a distance of 100 feet at levees and floodwalls.
- Provide a minimum of 1-foot of freeboard at top of creek banks, where overbank elevations are approximately equal or higher than top of bank elevations.

Design criteria for maintenance roads common to all project elements are:

- Provide a minimum maintenance road width of 18 feet, whenever possible.
- Maximum slopes on maintenance roads to be no greater than 10 percent.

Specific design criteria for each of the five project elements are described in the following subsections.

[32] City of Milpitas, *Berryessa Creek Trail and Coyote Creek Trail Feasibility Report – Administrative Draft*, March 30, 1999

4.1.1 Lower Berryessa Creek

The peak design flows for the Lower Berryessa Creek project element are based on flows developed by the District and Corps of Engineers and are shown in Table 4-1 below.

Table 4-1: Berryessa Creek Design Storm Flood Flows

Location	Design Flow (cfs)
Lower Penitencia Creek Above Confluence with Coyote Creek	9,050
Lower Penitencia Creek Below Confluence with Berryessa Creek	8,850
Berryessa Creek at Downstream End Immediately Above Confluence with Lower Penitencia Creek	7,200
Berryessa Creek at North Abel Street Below Confluence with Wrigley-Ford Ditch	6,900
Berryessa Creek at Berryessa Pump Station	5,960
Berryessa Creek Below Confluence with Tularcitos Creek	5,950
Berryessa Creek at Calaveras Boulevard	5,150
Berryessa Creek Below Confluence with Piedmont Creek	4,010
Berryessa Creek at Yosemite Rd	3,000
Berryessa Creek at Landess Road	2,810
Berryessa Creek Below Confluence with Sierra Creek (Morrill Rd)	2,250
Berryessa Creek Below Confluence with Crosley Creek	1,875
Berryessa Creek Below Confluence with Sweigert Creek	1,640
Berryessa Creek at Old Piedmont Road	1,540
Piedmont Creek at Mouth	1,200
Arroyo de Los Coches at Mouth	1,330
Tularcitos Creek at Mouth	845
Calera Creek at Mouth	880

Several other design criteria were established during development of the staff-recommended alternative for the Lower Berryessa Creek project element. These criteria are:

- Provide two 18-foot (minimum) wide maintenance roads along the entire project element. Locate an upper maintenance road at the top of the levee and a lower maintenance road on the inside of the floodwall.

- Set the elevation of the lower access approximately 5 to 6 feet above the low flow channel.
- Provide 12-foot wide turnouts spaced at approximately every 500 to 600 feet on lower maintenance road.
- The lower maintenance road shall continue through the railroad culvert and under street bridges at North Milpitas Boulevard and North Hillview Avenue. The lower maintenance road shall also ramp up for access at San Andreas Drive, Abel Street, North Milpitas Boulevard, North Hillview Avenue and the pedestrian bridge
- The upper maintenance road shall comply with Americans with Disabilities Act (ADA) accessibility requirements.
- Provide an opportunity for an approximately 6-foot to 18-foot wide vegetated bench approximately 3 feet above the low flow channel adjacent to inside toe of levee where hydraulic conditions allow.

4.1.2 Tularcitos Creek

The staff-recommended alternative for the Tularcitos Creek project element consists of a stormwater pump station and floodwalls to provide required freeboard during design flows.

The peak design flow for the Tularcitos Creek project element is 845 cfs, as provided in Table 4-1. The pump station shall be capable of 1) pumping the peak design flow; and 2) allowing gravity bypass of flows whenever hydraulic conditions permit.

Additional criteria for the design of the staff-recommended alternative for the Tularcitos Creek project element are:

- Provide maintenance roads on both banks of the channel. Maintenance road widths may vary and be less than the typical 18-foot wide District standard to accommodate right of way constraints.
- Raise existing pedestrian bridges as required to provide adequate freeboard and meet ADA accessibility requirements.

4.1.3 Lower Calera Creek

The peak design flow for the Lower Calera Creek project element is 880 cfs based on the Corps of Engineers flows as provided in Table 4-1. Additional criteria for this project element are:

- Provide one 18-foot wide (minimum) maintenance road along one side of the channel.
- Provide one 5-foot wide maintenance path along one side of the channel.
- Provide an opportunity for an approximately 15-foot to 30-foot wide vegetated bench approximately 1 to 2 feet above the low flow channel adjacent to inside toe of levee where hydraulic conditions allow.
- The existing drop structure is to remain

4.1.4 Upper Calera Creek Elements 1 and 2

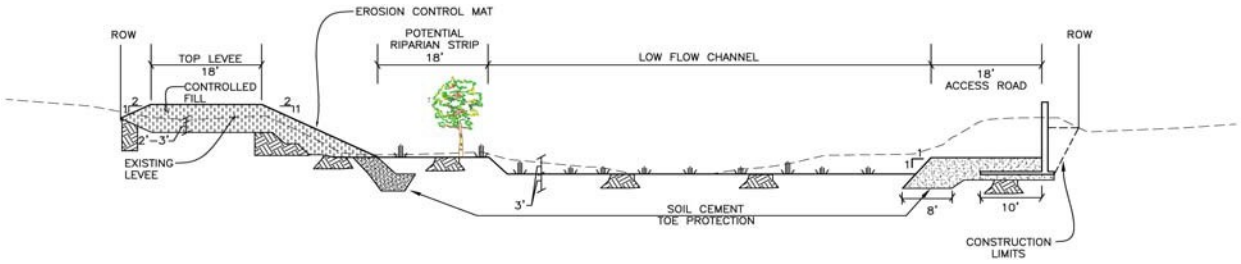
The peak design flow for Calera Creek Elements 1 and 2 is 880 cfs downstream of Highway 680 as provided in Table 4-1.

4.2 Staff-Recommended Alternative

4.2.1 Lower Berryessa Creek

The staff-recommended alternative for the Lower Berryessa Creek project element would reconstruct the existing levee on one side of the channel and replace the existing levee on the other side of the channel with a floodwall to contain peak design flows. Maintenance roads would be provided at the top of the reconstructed levee and along the inside of the floodwall adjacent to the channel. The maintenance road on the top of the levee would serve a portion of the City of Milpitas trail system. Ramps and turnouts along the roads would provide access for District maintenance staff and equipment. Riparian vegetation could be planted along the inside toe of the levee to enhance environmental qualities. Sediment would be regularly removed from the low-flow channel as part of the District's stream maintenance program (see Chapter 5), but any new riparian vegetation would be left mostly undisturbed. These basic components of the staff-recommended alternative are shown in Figure 4-1 and concept drawings are provided in Appendix D.

Figure 4-1: Lower Berryessa Creek Staff-Recommended Project Typical Section



To construct this staff-recommended alternative, the existing levee on one side of the channel would be partially excavated and prepared to receive new embankment fill. On the other side of the channel, the existing levee would be completely removed for construction of the floodwall. Some of the excavation spoils would be stockpiled onsite to be used in the work; excess material would be hauled away and disposed of offsite. The embankment fill for the reconstructed levee would consist of lime-treated stockpiled soils, imported fill or a combination of the two. The levee slopes would be planted with ground cover for erosion protection. The floodwall would be constructed of reinforced concrete. The lower maintenance road adjacent to the floodwall would be constructed of soil-cement using stockpiled soil. The upper maintenance road on the top of the

reconstructed levee would be paved with asphalt. Riparian vegetation would be selected from the District's recommended plant list and planted on an elevated earthen bench constructed using stockpiled soils. The reconstructed levee and new floodwall would tie into channel improvements at the railroad crossing designed and constructed by the VTA.

The Lower Berryessa Creek project element has seven distinct reaches defined by channel characteristics and/or adjacent land use, as shown in Figure 4-2. These are designated as Reach A through G. The concept design of the staff-recommended alternatives addresses the specific characteristics of each reach.

Reach A

Confluence with Lower Penitencia Creek to Confluence with Calera Creek

(Station 0+00 to 11+00)

Rear yards of residential properties are located on each side of the creek channel along Reach A as shown in Figure 4-3. The reconstructed levee would be located along the north bank of the channel to conform to the City of Milpitas trail master plan. The top of the levee would be about 6 feet above existing grade along the outside toe adjacent to residences. The trail's location on the top of the levee may result in privacy concerns by adjacent homeowners. In anticipation of these concerns, the outside toe of the levee would be located 10 feet from property lines, an increase over the typical 0 to 5-foot setback along other reaches. This increased setback is not sufficient to mitigate all anticipated privacy concerns, but is the maximum feasible setback that can be accommodated without compromising hydraulic performance and other project design criteria. The floodwall would be set back five feet from property lines, the practical minimum required for construction and maintenance of the wall. The floodwall extends approximately 7 feet above existing grade at the outside of the wall (adjacent to residences). Riparian vegetation could extend the full length of the reach along the inside toe of the levee, ending just downstream of the confluence with Calera Creek. At the downstream limits of this reach, the levee maintenance road would connect to the existing access road at Milmont Drive parallel to Lower Penitencia Creek and the lower maintenance road adjacent to the floodwall would ramp up and tie into San Andreas Drive. A soil-cement guide vane would help direct flows from Lower Berryessa Creek into Lower Penitencia Creek.

Figure 4-2: Lower Berryessa Creek Project Element and Reach Map

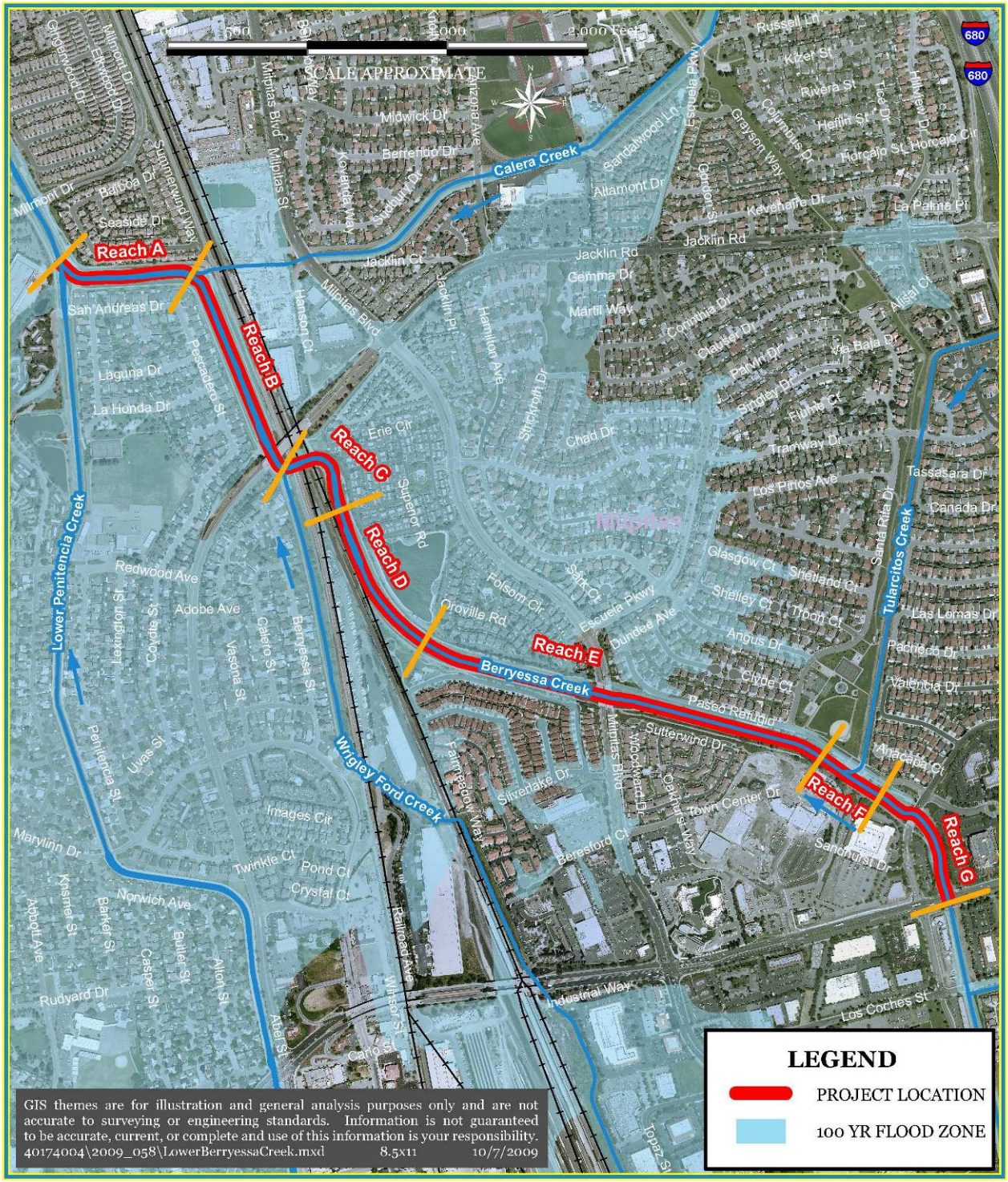
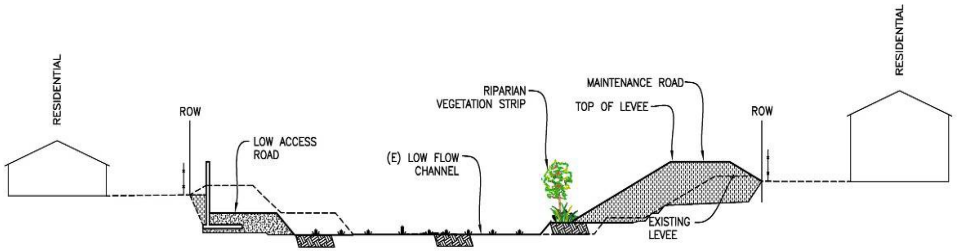
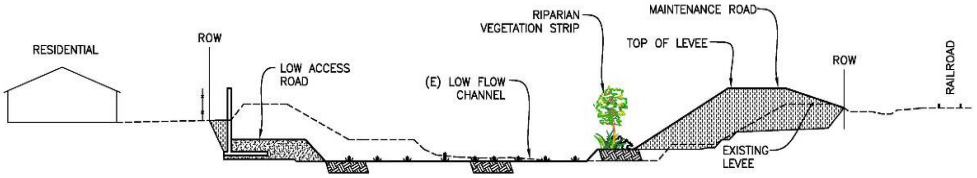


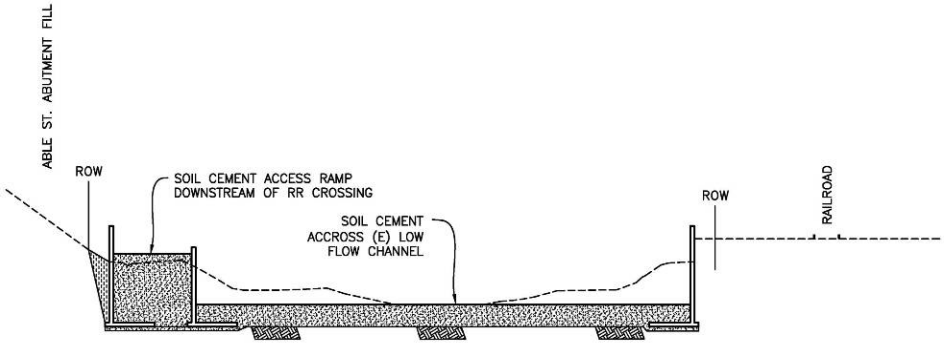
Figure 4-3: Lower Berryessa Creek Staff-Recommended Alternative Sections



TYPICAL SECTION REACH A
Looking Downstream

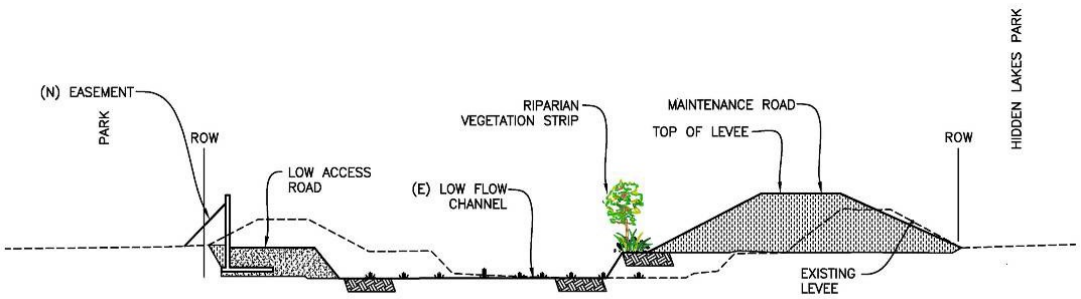


TYPICAL SECTION REACH B
Looking Downstream

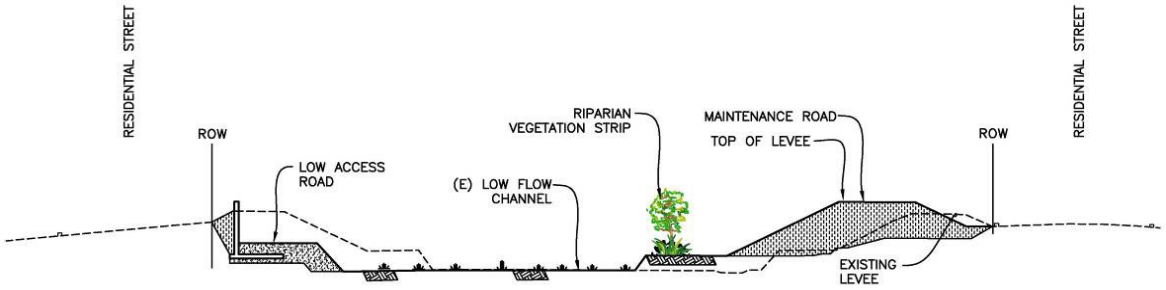


TYPICAL SECTION REACH C
Looking Downstream

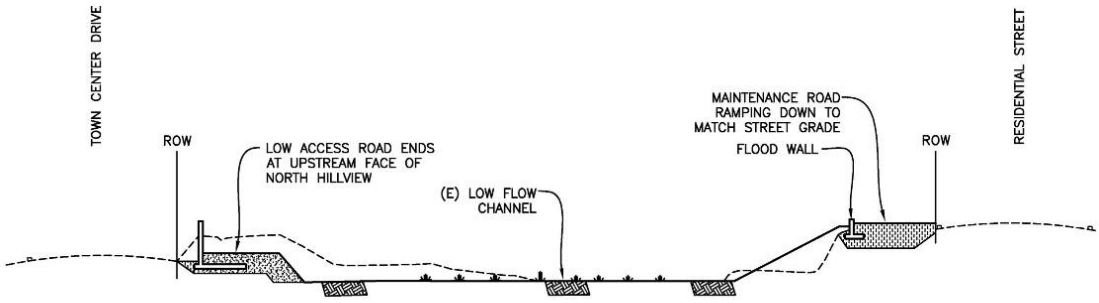
Figure 4-3: Lower Berryessa Creek Staff-Recommended Alternative Sections - continued



TYPICAL SECTION REACH D
Looking Downstream

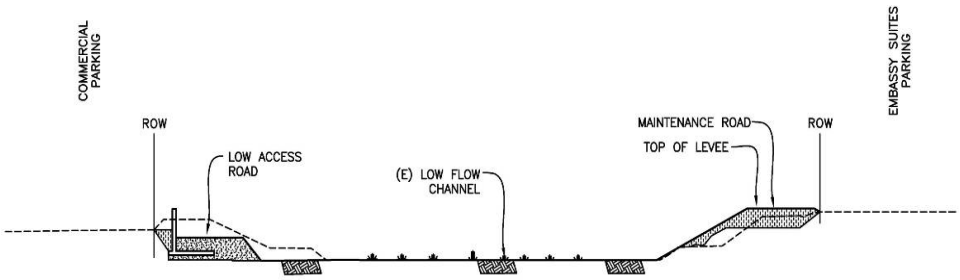


TYPICAL SECTION REACH E
Looking Downstream



TYPICAL SECTION REACH F
Looking Downstream

Figure 4-3: Lower Berryessa Creek Staff-Recommended Alternative Sections - continued



TYPICAL SECTION REACH G
Looking Downstream

Reach B

Confluence with Calera Creek to Able Street

(Station 11+00 to 25+00)

Railroad lines and commercial properties are located along the east side of Reach B, with rear yards of residential properties along the west side as shown in Figure 4-3. The reconstructed levee is located on the east bank of the channel to maximize the distance from the City of Milpitas trail on top of the levee to residential properties. A construction easement would be required from the railroad through this reach in order to construct the outside slope of the levee. The floodwall would be setback 5 feet from adjacent residential property lines, with a top of wall elevation about 8 feet above adjacent grade along the outside face. Riparian vegetation could extend the full reach along the inside toe of the levee. The lower maintenance road adjacent to the floodwall would ramp up at Abel Street and ramp back down behind the floodwall to tie into the existing access road for the Wrigley Ford Pump Station. The upper maintenance road would end at a turnaround just downstream of Abel Street and include a ramp access to the low flow channel just downstream of the railroad culverts. The existing bridge across Calera Creek would be reconstructed to match the new maintenance road elevation at the top of the reconstructed levee. Reconstruction would extend or replace the existing abutments and raise the railroad-car bridge superstructure to the required elevation. The Milpitas Trail System calls for a pedestrian crossing just downstream of Abel Street to connect the trail access from the west to the east side of the channel.

Reach C
Railroad Crossing
(Station 25+00 to 30+00)

Reach C is surrounded by commercial and industrial property as shown in Figure 4-3. By the time construction is scheduled to start for the Lower Berryessa Creek project element, new box culverts will have been constructed by Valley Transportation Authority (VTA) where Lower Berryessa Creek crosses under the existing railroad. The new culvert and associated channel improvements will eliminate a major hydraulic constriction. The levee on the east side of the channel along Reach B ends just downstream of Abel Street and would be replaced by a floodwall that extends to the headwall of the new culverts, as would the floodwall along the west side of Reach B. These floodwalls would continue upstream of the railroad crossing to Reach D, where the north floodwall ends and the reconstructed levee begins and where the south floodwall would continue. There would be no maintenance road on the north side of the channel. The low maintenance road on the south side of the channel would continue under the railroad through the southernmost box culvert. No riparian vegetation would be provided along this reach and the bottom of the channel downstream of the box culverts would be reconstructed using soil cement.

The realignment of the channel crossing at the railroad would require additional right of way from the railroad at both the downstream and upstream ends of this reach. The existing Abel Street Bridge piers located in the creek channel are being modified as part of the VTA Project.

Reach D
Railroad Crossing to Hidden Lake Park
(Station 30+00 to 43+00)

The railroad parallels the south side of the channel along Reach D as shown in Figure 4-3. Along the north side are homes separated by a residential street and the lake at Hidden Lake Park. The reconstructed levee would be located on the north side of the channel and the maintenance road on top would serve as a City trail. The top of the levee would be about 12 feet higher than the adjacent residential street, which serves as a buffer between adjacent homes. The floodwall would be located adjacent to the railroad and would be about five feet higher than the railroad bed. Riparian vegetation could be provided along the entire reach adjacent to the inside toe of the levee.

Reach E
Hidden Lake Park to Berryessa Creek Trail Pedestrian Bridge
(Station 43+00 to 72+00)

Upstream of Hidden Lakes Park there are residential subdivisions on both sides of the channel with residential streets separating the levee and floodwall from homes as shown in Figure 4-3. The reconstructed levee would be on the north side and the floodwall on the south side of the channel. The tops of the reconstructed levee and floodwall would be about 12 feet higher than the adjacent street (about 3 feet higher than the existing levees).

The City trail would continue on top of the levee from Reach D to the existing pedestrian bridge, which would be temporarily removed during construction and replaced at a higher elevation. The trail then crosses over the bridge into the Town Center retail development. Riparian vegetation could be provided throughout this reach except for approximately 200 feet downstream and 300 feet upstream of North Milpitas Blvd. The lower maintenance road adjacent to the floodwall would ramp up to North Milpitas Blvd. from both sides of the crossing and also continue under the bridge crossing, ramping up again to the new pedestrian bridge elevation. A new headwall along the upstream face of the North Milpitas Blvd. Bridge would be required to meet the requirement for 4-foot freeboard at bridges. A ramp from the pedestrian bridge down to the Town Center retail development will be required.

Reach F

Berryessa Creek Trail Pedestrian Bridge to Confluence with Tularcitos Creek

(Station 72+00 to 76+00)

On the north side of Reach F is Peter T. Gill Park and to the south is the Town Center retail development. Just upstream of the Berryessa Creek Trail Pedestrian Bridge, the Hetch Hetchy water distribution mains (78 inch and 96 inch pipes) cross underneath Berryessa Creek. The levee on the north side of the channel would ramp down from both sides of the Hetch Hetchy crossing to match existing grade at Paeso Refugio, providing access to the maintenance road and trail at the top of the levee. The resulting top of levee elevation would not meet freeboard requirements. A short (approximately 2 feet high) concrete floodwall located on the outside edge of the top of the levee would provide the necessary freeboard. The lower maintenance road adjacent to the floodwall on the south side of the channel would ramp down from the pedestrian bridge to its typical elevation approximately 5 to 6 feet above the low flow channel. The top of the reconstructed levee would only be slightly (less than 1 to 4 feet) higher than the adjacent grade at Paseo Refugio. The floodwall would extend about six feet above the adjacent ground at the outside face of the levee. No riparian vegetation would be provided along this reach due to the restricted channel configuration and existing concrete construction in the vicinity of the Hetch Hetchy crossing.

Reach G

Confluence with Tularcitos Creek to Calaveras Boulevard

(Station 76+00 to 86+00)

On the north side of this reach, going upstream, there is swath of undeveloped land followed by the parking lot for the Embassy Suites Hotel as shown in Figure 4-3. To the south are Milpitas City hall and a parking lot for a commercial property. The levee on the north side of the channel would ramp up from both sides to the North Hillview Dr. road crossing. Upstream of North Hillview Dr., the levee would abut the parking lot for Embassy Suites. Access to the top of the levee would be from this parking lot, as direct access onto busy Calaveras Boulevard would be difficult and potentially dangerous. The lower maintenance road adjacent to the floodwall on the south side of the channel would ramp up on both sides of North Hillview Dr. and also continue under the bridge where it would dead end. The North Hillview Drive Bridge is high enough to provide for the

required 3 feet of freeboard downstream and 4 feet of freeboard upstream. No riparian vegetation would be provided along this reach because of the restricted channel configuration and widening of the lower maintenance road under North Hillview Drive.

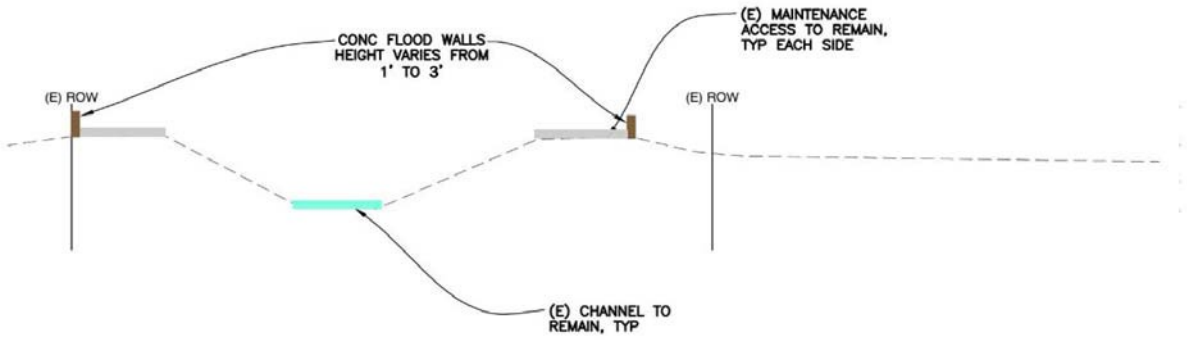
4.2.2 Tularcitos Creek

The staff-recommended alternative for the Tularcitos Creek project element would be to construct a storm water pump station near the confluence with Berryessa Creek to lower the hydraulic grade line, thus providing additional channel capacity upstream to convey peak design flows. Even with this additional capacity, short concrete floodwalls would be required upstream of the pump station to provide adequate freeboard and existing road and pedestrian bridges would need to be modified.

The pump station would be located within the existing Tularcitos Creek channel adjacent to Paseo Refugio. Two 1,280 horsepower diesel engine driven pumps would provide the capacity to convey 845 cubic feet per second into Berryessa Creek. A third pump would be provided for redundancy. Pumps would be activated only when the water surface in Berryessa Creek is high enough to prevent flows from Tularcitos Creek from being conveyed via a gravity bypass through the pump station. The pumps would be housed in a masonry building that would be located over an underground wet well in which the pump intakes are located. The building would be about 100 feet by 75 feet in area and the roof would be about 30 feet above the existing creek banks. The pumps would discharge into a concrete outlet structure that directs flows through a box culvert and existing concrete channel into Berryessa Creek. A schematic layout and major components of the pump station are shown on the concept drawings provided in Appendix D.

The height of the floodwalls would range from a minimum of 6 inches to approximately 3 feet above the existing grade. Maintenance roads would be provided on both sides of the channel, but would be narrower than the District's 18-foot recommended width, about 15 feet (east bank) and 10 feet (west bank) wide due to the limited right of way. The staff-recommended alternative would not include any significant improvements to the existing channel, except as required to accommodate the new pump station. It is anticipated that regular sediment removal would be required from the pump station wet well as part of the District's stream maintenance program (see Chapter 5). A typical section of the channel is illustrated in Figure 4-4 and additional information shown on the concept drawings provided in Appendix D.

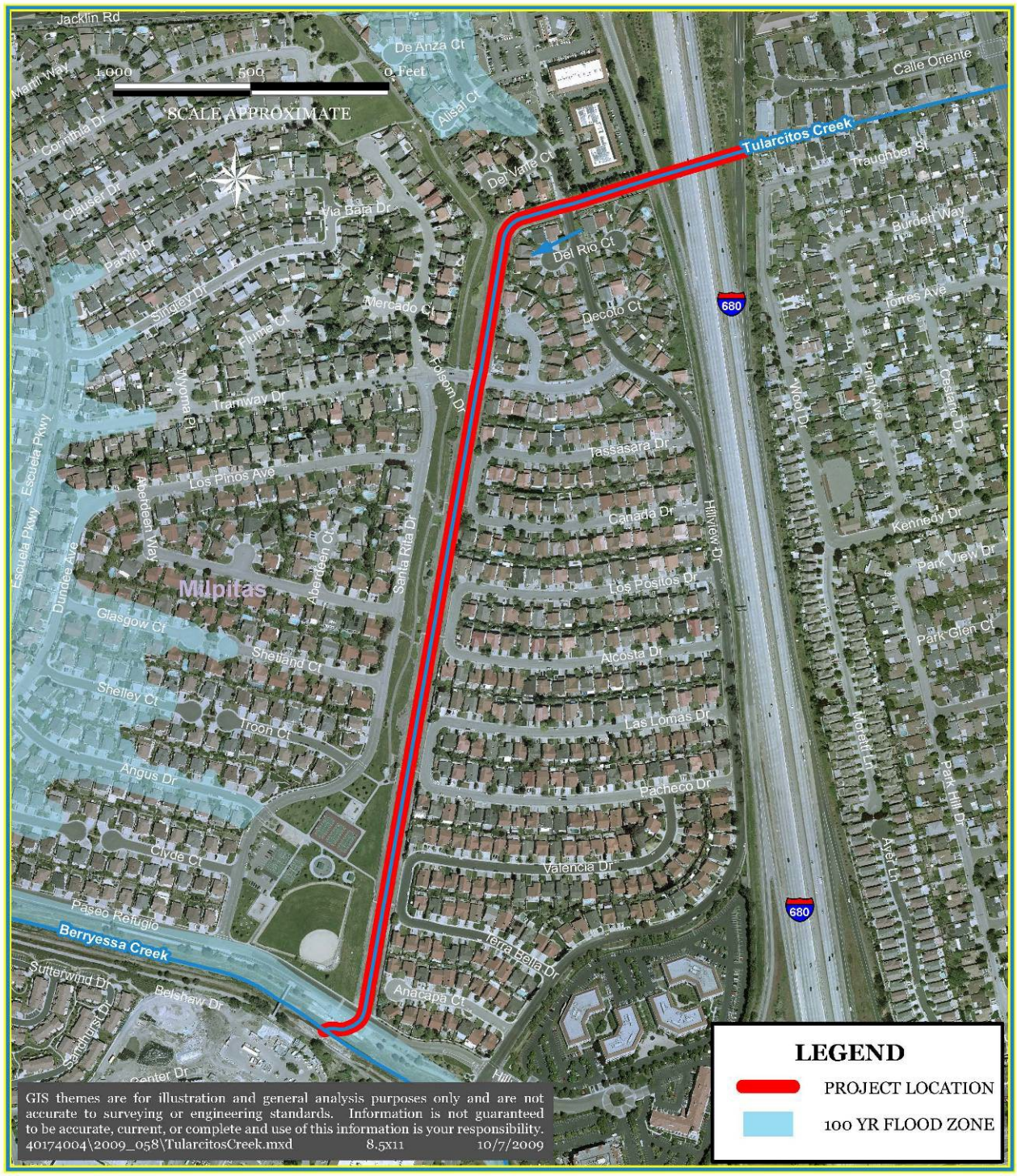
Figure 4-4: Tularcitos Creek Staff-Recommended Alternative Typical Section



The first step in constructing the pump station would be to excavate the existing creek bed for the wet well and inlet channel. The spoils from this excavation would be hauled offsite. Reinforced concrete would then be placed for the base slab and walls for the wet well, inlet channel and outlet structure. Construction of the pump station building and installation of the pump equipment would follow.

To construct the floodwalls, the existing creek banks would be excavated for the wall footings and reinforced concrete placed for the walls and their foundations. The subgrade of the existing maintenance roads would be prepared to allow placement and compaction of aggregate base course for the maintenance roads. Existing pedestrian bridges would be temporarily removed and then replaced on new concrete abutments. New concrete head walls would be added to existing road bridges at Paseo Refugio, Tramway Drive and N. Hillview Drive. The extent of the Tularcitos Creek project element is shown in Figure 4-5.

Figure 4-5:Tularcitos Creek Project Element Map

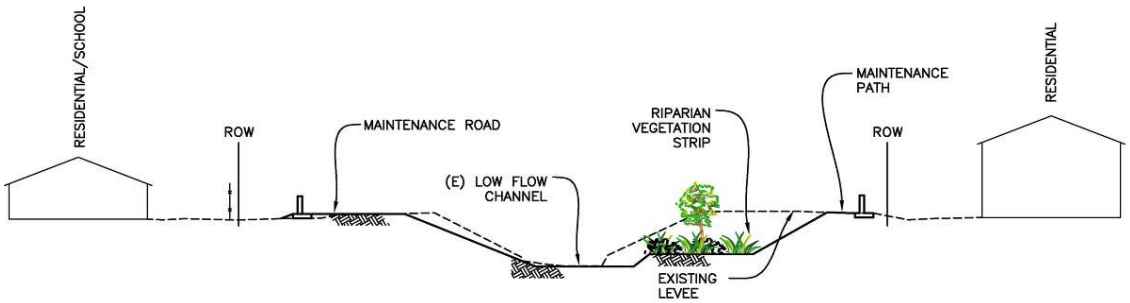


4.2.3 Lower Calera Creek

The staff-recommended alternative for the Lower Calera Creek project element would be to reconfigure the channel and provide concrete floodwalls on each side of the channel to contain peak design flows. The new channel would be wider than the existing channel and allow planting riparian vegetation along the toe of one bank, similar to the staff-recommended alternative for Lower Berryessa Creek. An 18-foot wide maintenance road would be provided at the top of one bank and 5-foot wide maintenance path would be provided on the opposite top of bank. At the downstream end of the reach, the sides of an existing concrete channel would be augmented to provide required freeboard.

Construction of the staff-recommended alternative would include excavation of the existing channel with the spoils hauled off site. Reinforced concrete floodwalls would be constructed on both sides of the channel and aggregate base course placed for the maintenance road. Riparian vegetation would be selected from the District's plant list and planted on an earthen bench. These basic components of the staff-recommended alternative are shown in Figure 4-6 and concept drawings are provided in Appendix D.

Figure 4-6: Lower Calera Creek Staff-Recommended Alternative Typical Channel

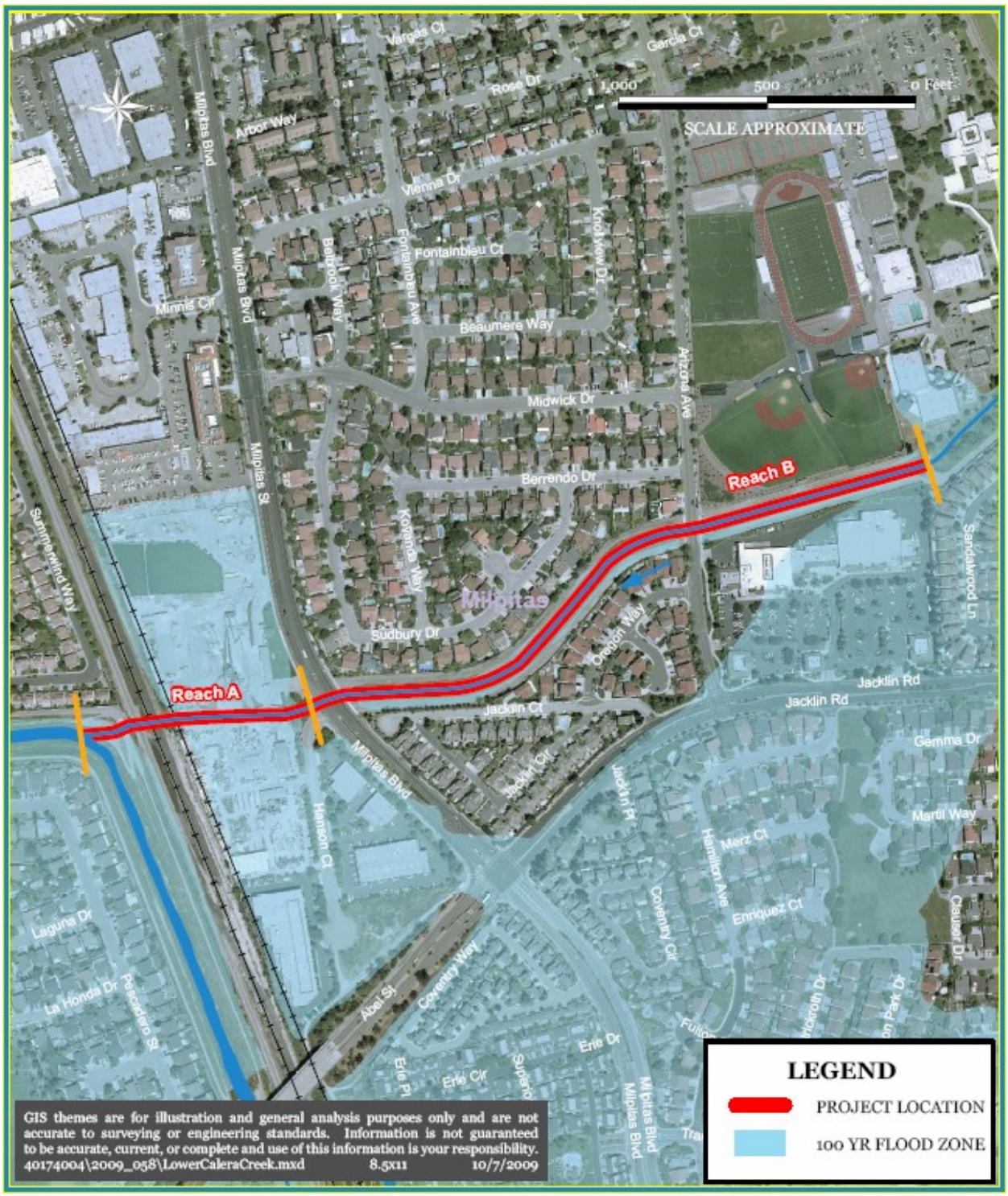


TYPICAL SECTION REACH B
Looking Downstream

To construct this staff-recommended alternative, one access road would be removed and the bank excavated at a 2:1 side slope to provide for an in-channel vegetated bench. The excavated material would be hauled away and disposed of offsite.

The Calera Creek project element has two distinct reaches defined by channel characteristics as shown in Figure 4-7 and designated as Reach A and B.

Figure 4-7: Lower Calera Creek Project Element and Reach Map



Reach A

Confluence with Berryessa Creek to Milpitas Boulevard

(Station 0+50 to 8+00)

This reach begins at the confluence with Berryessa Creek adjacent to the railroad and extends through an industrial site to the west of Milpitas Boulevard as shown in Figure 4-8. The creek is contained in a vertical walled concrete channel connected at each end to existing culverts under the railroad (downstream end) and Milpitas Blvd (upstream end). The walls of the existing channel would be extended[33] about 3 to 4 feet, and new headwalls provided at the railroad crossing and Milpitas Boulevard culverts would provide the required freeboard. The existing maintenance ramp into the channel would be reconstructed.

Reach B

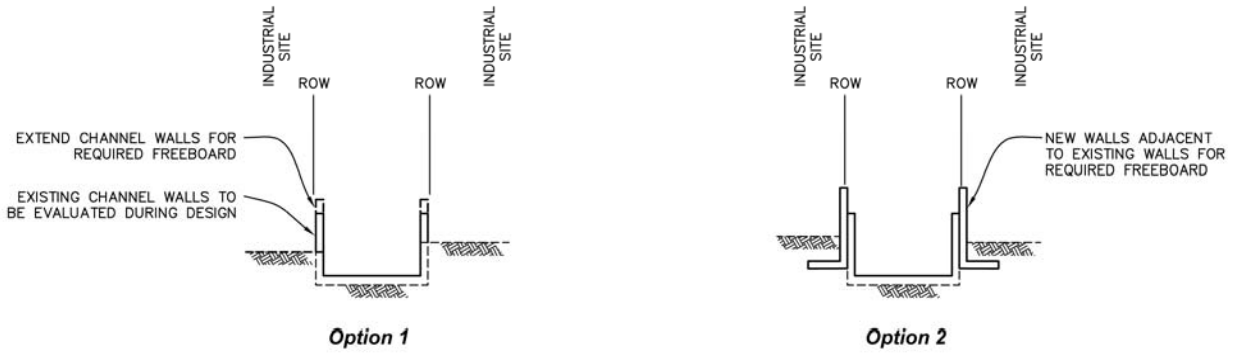
Milpitas Boulevard to the Existing Drop Structure

(Station 9+00 to 31+26)

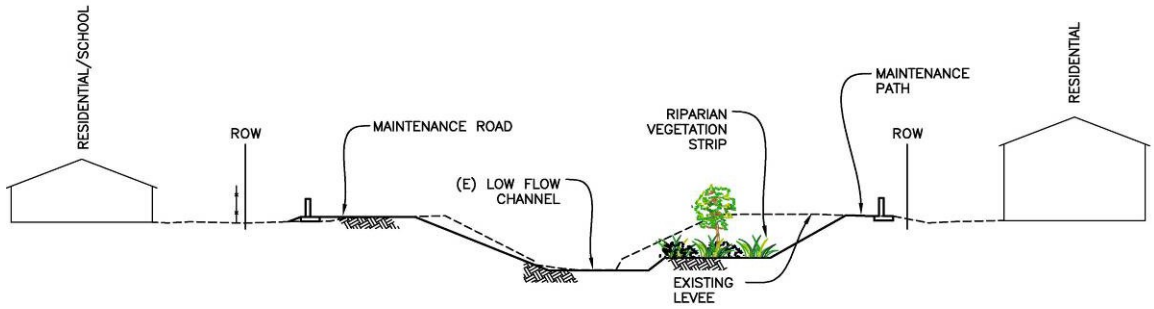
Upstream of Milpitas Boulevard the creek consists of an earthen trapezoidal channel with rear yards of residential properties bordering on both sides as shown in Figure 4-8. Upstream of Arizona Avenue, Milpitas High School grounds are located to the north of the channel and a shopping center is located on the south side. The existing banks on both sides of the channel are approximately level with or slightly higher than the adjacent ground. The maintenance road would be located on the south bank to align with the maintenance road in Upper Calera Creek Element 1 above the drop structure. Riparian vegetation could be located along the toe of the north bank. The outside faces of the new floodwalls are set 5 feet inside of the right of way on both sides of the channel. Floodwall heights would range from 3 to 6.5 feet on both sides of the channel downstream of Arizona Avenue. Upstream of Arizona Avenue, the floodwalls would range in height from 3.5 to almost 6 feet on the south side of the channel, and 2 to 5 feet on the north side. Headwalls would be required at the upstream face of the culvert at Milpitas Boulevard and the downstream and upstream faces of the Arizona Avenue culvert. Access to the maintenance road would be provided at each street crossing via ramped sections over the floodwalls. The Lower Calera Creek project element ends just upstream of the existing drop structure where it connects to the improvements for Upper Calera Element 1. No improvements to the drop structure would be required.

[33] A structural evaluation of the existing concrete channel walls will be conducted during design. If the existing walls have sufficient capacity, they will be extended by casting new concrete on top of them. If the existing walls do not have sufficient capacity, they will be augmented by new, structurally independent concrete walls.

Figure 4-8: Lower Calera Creek Staff-Recommended Alternative Sections



TYPICAL SECTION REACH A
Looking Downstream

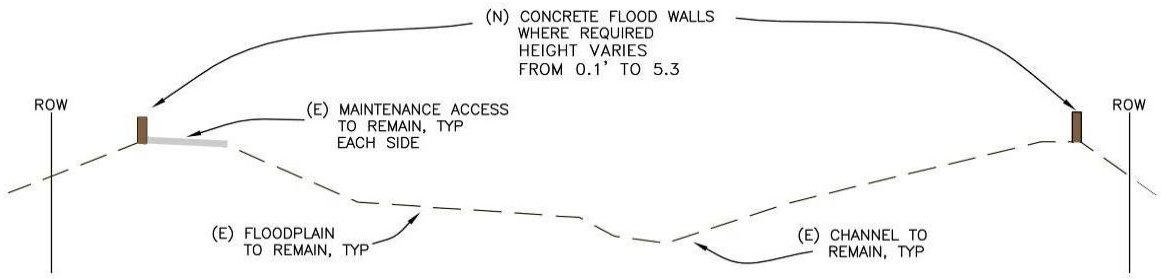


TYPICAL SECTION REACH B
Looking Downstream

4.2.4 Upper Calera Creek Element 1

The staff-recommended alternative for Upper Calera Creek Element 1 would be to construct floodwalls on each side of the existing channel to contain peak design flows. The existing channel would remain unchanged. Existing maintenance roads, some narrower than the District's minimum recommended width of 18 feet, would remain. Raised headwalls would be required at the downstream and upstream face of Escuela Parkway to provide adequate freeboard. The basic components of the staff-recommended alternative are shown in Figure 4-9 and concept drawings are provided in Appendix D.

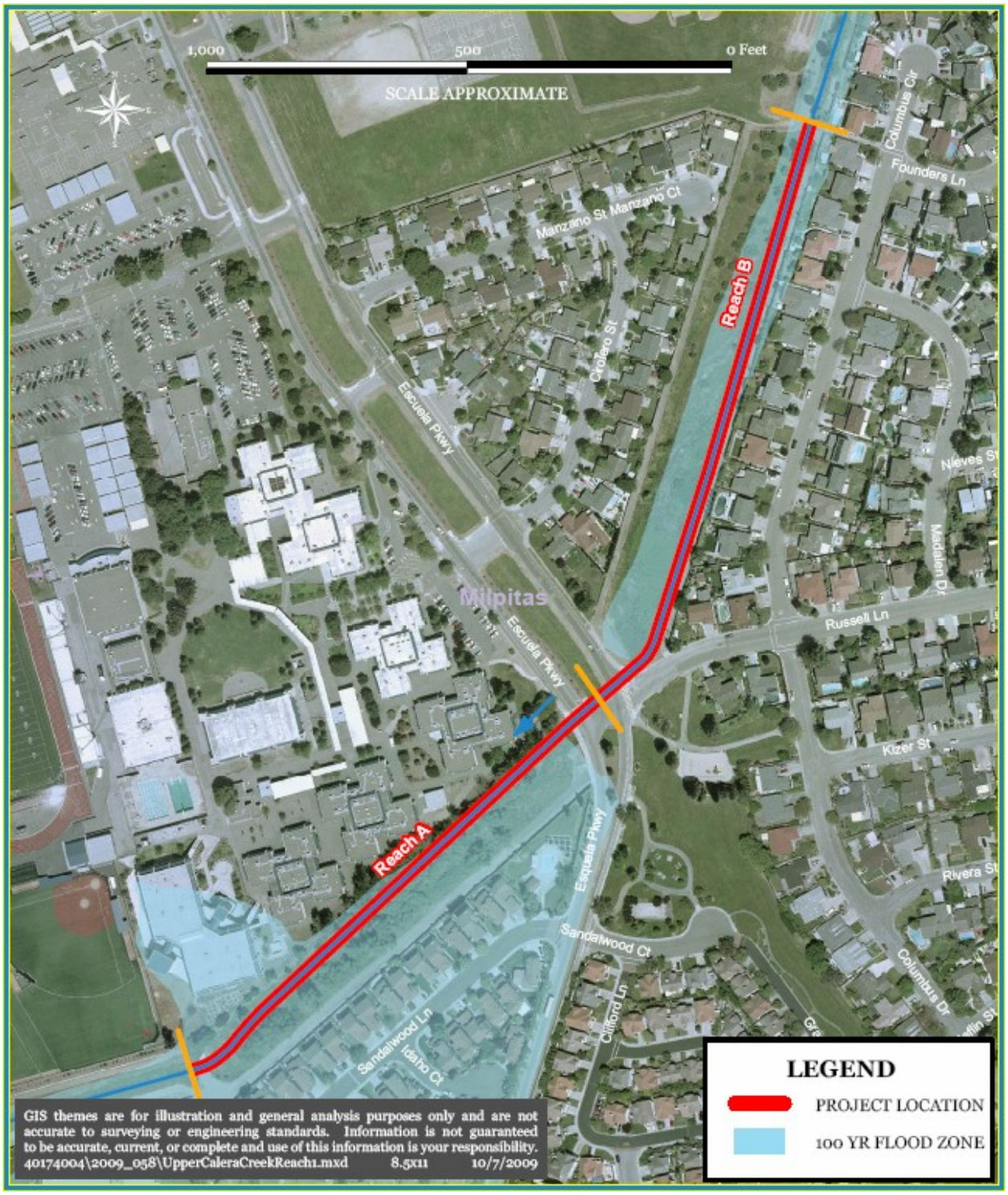
Figure 4-9: Upper Calera Creek Element 1 Typical Section



To construct this recommend alternative, the existing maintenance road or channel bank would be excavated to construct the floodwalls and their foundations. The existing maintenance roads would be re-graded and a new aggregate base course road section constructed. All excess materials would be hauled away and disposed of offsite.

Upper Calera Creek Element 1 has two distinct reaches defined by channel characteristics as shown in Figure 4-10 and designated as Reach A and B.

Figure 4-10: Upper Calera Creek Element 1 and Reach Map



Reach A

Drop Structure to Escuela Parkway

(Station 31+25 to 40+20)

This reach extends from the drop structure upstream to Escuela Parkway as shown in Figure 4-11. Milpitas High School is located adjacent to the north side of the channel and rear yards of residences are located on the south side of the channel. The new floodwalls would be located five feet inside the existing right of way and would extend about 2 to 6 feet higher than the existing creek bank. There is no maintenance road adjacent to the high school, so construction of the floodwall on the north would require construction easements. A single 18-foot wide maintenance road would be located on the south side of the channel. Access to this maintenance road would be from a continuation of the maintenance road from the downstream Lower Calera Creek project element and via ramps at the Escuela Parkway crossing.

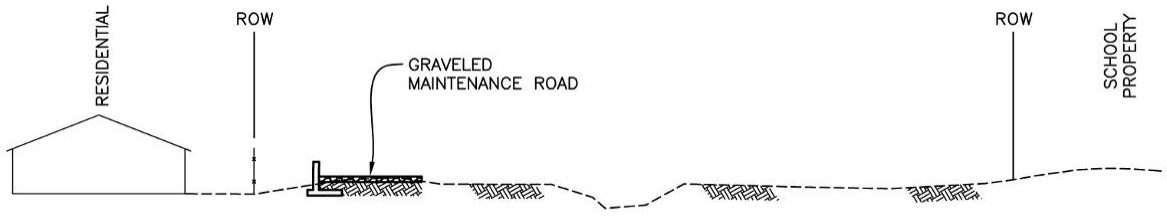
Reach B

Escuela Parkway to Existing Pedestrian Bridge

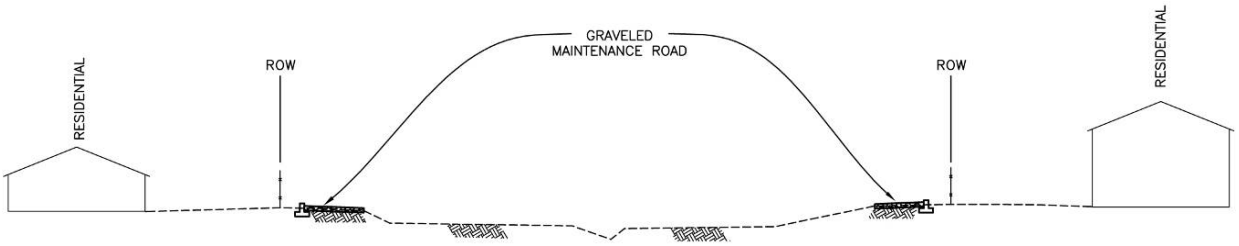
*(*Station *42+00 to 53+00)*

Rear yards of residential properties are located on each side of the creek channel along Reach B as shown in Figure 4-11. The new floodwalls would be located 5 feet inside the right of way and top of wall elevations would be about one foot to 3 feet above adjacent existing ground. Existing 10-foot wide (with a short section only 8 feet wide on the west bank) maintenance roads on both sides of the channel will remain. The existing roads cannot be widened to satisfy District recommendations due to limited access and the desire to protect the existing channel from construction impacts.

Figure 4-11: Upper Calera Creek Element 1 Staff-Recommended Alternative Typical Sections



TYPICAL SECTION REACH A
Looking Downstream

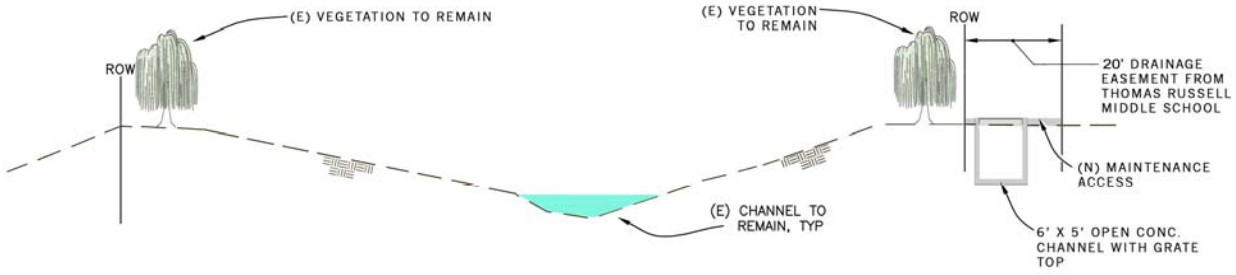


TYPICAL SECTION REACH B
Looking Downstream

4.2.5 Upper Calera Creek Element 2

The staff-recommended alternative for Upper Calera Creek Element 2 is an open 6 feet wide by 5 feet deep concrete bypass channel on the west side of the creek, which would be located within a new 23-foot easement to be obtained from Thomas Russell Middle School. A side channel weir located just downstream of Interstate 680 (I-680) would allow high flows to spill into the bypass channel, and discharge into the existing creek channel downstream of the pedestrian bridge. The restricted channel at the pedestrian bridge at the downstream limits of this project element would be widened and the pedestrian bridge replaced. Upstream of I-680, approximately 200 feet of the existing creek channel would be reconstructed to remove a drop structure at the north end of Jose Hugera Park, and a short concrete floodwall would be constructed on the west side of the creek at the upstream limits of this project element to provide adequate freeboard. These upstream improvements would also be located outside District right of way and would require both construction easements and permanent drainage easements. The staff-recommended alternative would not include any improvements for maintenance access. The basic components of the staff-recommended alternative are shown in Figure 4-12 and concept drawings are provided in Appendix D.

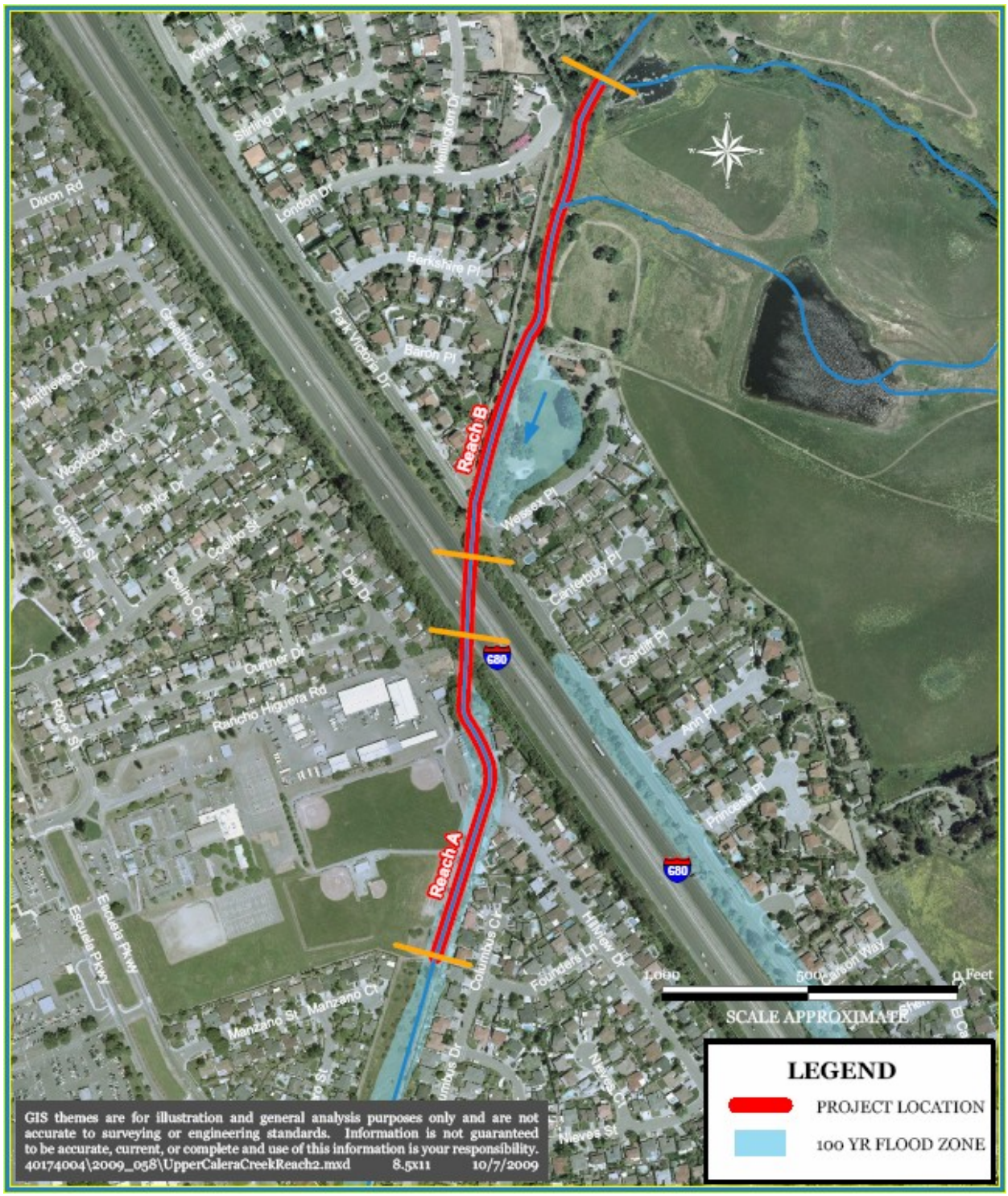
Figure 4-12: Upper Calera Creek Element 2 Staff-Recommended Alternative - Gravity Bypass



To construct this staff-recommended alternative a trench would be excavated along the bypass channel alignment. The existing channel and mature trees on both sides of the creek would be protected. The excavated material would be hauled away and disposed of offsite. The bypass channel would most likely be cast-in-place, although pre-cast concrete could be considered as an option. The bypass channel would be covered with a galvanized steel grate capable of supporting truck traffic loads. The reconstructed channel upstream of I-680 in the park would require excavation and revegetation. The channel would also require a short sheetpile wall along the easterly edge so that an existing large tree near the bank could remain.

Upper Calera Creek Element 2 has two distinct reaches defined by channel characteristics as shown in Figure 4-13 and designated as Reach A and B.

Figure 4-13: Upper Calera Creek Element 2 and Reach Map



Reach A

Existing Pedestrian Bridge to I-680

(Station 53+00 to 63+50)

This section of the project element passes through a narrow (60-foot) right of way with mature trees on both banks. Thomas Russell Middle School is located adjacent to the west bank and rear yards of residential properties are located on the east side of the creek channel. A short section of floodwall on the east side of the channel would be required to tie into the floodwall for Upper Calera Element 1. The existing pedestrian bridge would be replaced by a new pedestrian bridge over the widened channel section. The bypass channel would be constructed in the new 15-foot easement.

Reach B

Upstream of I-680/N. Park Victoria Drive to London Drive

(Station 63+50 to 84+00)

This reach passes through Jose Hugera Adobe Park and through private property to the upstream limits of the project element. At the upstream limit of the portion of the channel in the park, an existing drop structure severely restricts flow and would be removed and the channel reconstructed. This work would reduce the overtopping of the creek banks that currently occurs in this reach and would protect the buildings on park property. At the upstream limits of the project element, additional freeboard would be required to prevent potential overtopping on the west bank and flooding onto London Drive. A 2-foot high floodwall approximately 130 feet in length would provide the required freeboard. All the work in this reach would be outside of District right of way. Existing District right of way in this reach provides for a maintenance road parallel to the west channel bank; however, the channel itself, for the most part, is outside this right of way.

4.3 Right of Way Requirements

4.3.1 Lower Berryessa Creek

Reach A

Confluence with Lower Penitencia Creek to Confluence with Calera Creek

(Station 0+00 to 11+00)

No additional right of way is anticipated in this reach.

Reach B

Confluence with Calera Creek to Abel Street

(Station 11+00 to 25+00)

The levee in this reach would run parallel to the railroad right of way and the outside toe would catch existing grade very close to the existing right of way. This would require that an approximately 10-foot wide construction easement be obtained from the railroad to construct the outside levee face. The turnaround at the upstream limits of this reach at station 23+50 would require a permanent fill easement from the railroad. The lower

maintenance road would ramp up at Abel Street and would require an access easement from the City of Milpitas.

Reach C

Railroad Crossing

(Station 25+00 to 30+00)

The channel realignment and culvert construction in this reach would require additional right of way from the railroad. A wider right of way from the railroad would be required upstream of the box culvert crossings to provide for a lower maintenance road turnaround. An access easement from the City of Milpitas would be required to tie the Abel street maintenance road ramp with the City access road to the Wrigley Ford Pump Station.

Reach D

Railroad Crossing to Hidden Lake Park

(Station 30+00 to 43+00)

No additional right of way is anticipated in this reach.

Reach E

Hidden Lake Park to Berryessa Creek Trail Pedestrian Bridge

(Station 43+00 to 72+00)

The lower maintenance road connection to North Milpitas Boulevard would appear to fit within an existing, wider District right of way for the existing levee access. A new floodwall on the upstream face of North Milpitas would require an easement from the City of Milpitas. The reconstruction of the existing pedestrian bridge access ramps at Town Center and Paseo Refugio would probably require easements from the City of Milpitas and private property owners.

Reach F

Berryessa Creek Trail Pedestrian Bridge to Confluence with Tularcitos Creek

(Station 72+00 to 76+00)

The levee maintenance road from Paseo Refugio would require an access easement from the City of Milpitas. In addition, the proposed floodwall along the outside face of the levee maintenance road would need to be tied into a new headwall on the Tularcitos Creek crossing of Paseo Refugio, requiring an easement from the City of Milpitas.

Reach G

Confluence with Tularcitos Creek to Calaveras Boulevard

(Station 76+00 to 86+00)

The use of the recommend maintenance road access at the Embassy Suites parking area would require an access easement.

4.3.2 Tularcitos Creek

The staff-recommended alternative for Tularcitos Creek would involve construction of a storm water pump station just upstream of Paseo Refugio and floodwalls along the outside edge of the existing maintenance roads on top of both banks. A tie to the Lower Berryessa Creek project element would be required downstream of Paseo Refugio. A floodwall along the outside edge of the Lower Berryessa Creek levee, to provide the necessary freeboard, would connect to a headwall on the downstream face of the Paseo Refugio Bridge. This work would require an easement from the City of Milpitas. In addition, headwalls would be required at the downstream and upstream faces of the North Hillview and Tramway culvert crossings that would also require easements from the City of Milpitas. Two pedestrian bridges would be raised and would require modification to the ADA access that would likely encroach outside of the existing District right of way. In addition, a 50-foot wide by 130-foot long easement will be required from the City of Milpitas for access to the pump station.

4.3.3 Lower Calera Creek

A headwall on the downstream and upstream face of the railroad bridge crossing, just upstream from the confluence with Berryessa Creek, would require an easement from the Union Pacific Railroad. From the railroad culverts upstream to Milpitas Boulevard, the channel consists of a concrete vertical walled section. The concrete walls will need to be extended to provide adequate freeboard. As a minimum, a construction easement would be required through this reach. Some permanent right of way may be necessary, if design details require the outside face of the new walls to extend beyond the face of the existing walls. A permanent right of way would be required to provide a modified access ramp from Milpitas Boulevard down into the concrete channel. Headwalls would be required at the downstream and upstream face of Milpitas Boulevard and Arizona Avenue, requiring easements from the City of Milpitas.

4.3.4 Upper Calera Creek Element 1

A construction easement would likely be required from Milpitas High School to gain access to construct the floodwall along the north side of the channel. A headwall on the downstream and upstream face of Escuela Parkway would be needed thus requiring an easement from the City of Milpitas.

4.3.5 Upper Calera Creek Element 2

The staff-recommended alternative calls for the construction of an open 6-foot deep by 5-foot wide concrete box bypass along the north side of the channel, constructed within a proposed new 20-foot wide drainage easement on Thomas Russell Middle School property from the downstream limits of Upper Calera Creek Element 2 to the downstream face of the I-680 culvert crossing. An additional 20-foot wide construction easement is also recommended. Upstream of I-680, a 200-foot section of the creek would be reconstructed to remove an existing drop structure. This portion of the channel is outside the existing District right of way and would require not only a permanent easement, but construction easements from the City of Milpitas and the property owner adjacent and upstream of Jose Hugera Adobe Park. A short length of floodwall

would also be required at the upstream limits of this project element, requiring both a permanent easement and construction easement to construct.

4.4 Best Management Practices

The District's Best Management Practices (BMP) handbook (District ISO Document No. W751M01) would be used during construction activities.

CHAPTER 5. MAINTENANCE PROGRAM

CHAPTER 5 MAINTENANCE PROGRAM

5.1. Previous Maintenance Activities

Maintenance work has been conducted within the Lower Berryessa Creek Project area over the last few decades. Regular maintenance has been limited to Lower Berryessa Creek with only sporadic maintenance in Tularcitos and Calera Creeks.

5.1.1. Lower Berryessa Creek

Large quantities of sediment have been removed from Lower Berryessa Creek by District crews in an ongoing effort to maintain flow capacity in the channel. Sediment removal records for the Project reach are shown in Table 5-1 and have been kept by the District since the Project reach was re-aligned to its current location in 1976. The District has current regulatory approvals that allow dredging one half of the channel in any given year.

In addition to sediment removal, the District conducts the following maintenance activities along Lower Berryessa Creek:

- Vegetation control on and adjacent to levees by mowing and spraying
- Rodent control by trapping and baiting
- Maintenance road repair and preventative maintenance and spraying
- Erosion damage repair to levees and lower maintenance roads
- Trash removal and debris removal at bridges and along access roads and in the channel
- Natural and low-flow channel maintenance
- Graffiti abatement

Table 5-1: Sediment Removal in Lower Berryessa CREEK (1977 to 2009)

Fiscal Year (FY)	Description	Stream Length (ft)	Sediment Removed (yd^3)
1981	Berryessa Creek, Calaveras Blvd D/S to WPRR	6100	4210
1982	Berryessa Creek, D/S from Calaveras Blvd to Lower Penitencia Creek	8600	23510
1985	Berryessa Creek, Lower Penitencia confluence to SPRR	2200	19500
1986	Berryessa Creek, Calaveras Blvd D/S to SPRR	6400	14352
1987	Berryessa Creek, Lower Penitencia Creek to Jacklin	2400	360
1987	Berryessa Creek, U/S Abel Street	10	460
1987	Berryessa Creek, U/S Abel Street Culvert	20	460
1987	Berryessa Creek, Lower Penitencia Creek to Jacklin	2400	9000
1989	Berryessa Creek, Calaveras Blvd D/S to SPRR	6300	13330
1990	Berryessa Creek, D/S Calaveras Blvd.	8900	7100
1991	Berryessa Creek, D/S SPRR	2400	3420
1992	Berryessa Creek, D/S SPRR	2400	4066
1994	Berryessa Creek, D/S Calaveras Blvd.	3100	2800
1998	Berryessa Creek, D/S Los Coches Creek	9350	30000
1999	Berryessa Creek, Lower Penitencia Creek to Calaveras Blvd	8600	33040
2004	Berryessa	-	2316
2005	Berryessa	-	7730
2007	Berryessa	-	3980
2008	Berryessa	-	6980
2009	Berryessa	-	964

5.1.2. Tularcitos Creek

The District has conducted periodic sediment removal from the Berryessa Creek confluence upstream to the I-680 crossing, the most recent occurring with the removal of 595 cubic yards in 2005. There have been no erosion control (bank repair) efforts within the Project reach. The District also conducts the following maintenance activities along Tularcitos Creek:

- Vegetation control by mowing and spraying
- Maintenance road grading, repair and preventative maintenance and spraying
- Trash removal and debris removal along access roads and in the channel

5.1.3. Lower Calera Creek

The District has conducted periodic sediment removal efforts on Calera Creek from the Berryessa Creek confluence upstream to the existing drop structure. There have also been some erosion control (bank repair) efforts along this reach of the creek. Sediment removal records from the District for are shown in Table 5-2

Table 5-2: Sediment Removal in Lower Calera Creek (2002 to 2009)

Fiscal Year (FY)	Sediment Removed (yd3)
2002	921
2003	2,100
2008	1,208

The District also conducts the following maintenance activities along Lower Calera Creek:

- Vegetation control by mowing and spraying
- Maintenance road grading, repair and preventative maintenance
- Trash removal and debris removal along the access roads and in the channel

5.1.4. Upper Calera Creek Element 1

The District has conducted periodic sediment removal downstream of Escuela Parkway to the drop structure and also just upstream of Escuela Parkway adjacent to the sack concrete lined channel. The District has also been monitoring the channel just downstream of the pedestrian bridge where the channel suddenly widens, causing sediment accumulation and were considering

a sediment removal project at the site at the time this report was being prepared. The District also conducts the following maintenance activities along this reach of Upper Calera Creek Element 1:

- Vegetation control by mowing and spraying
- Maintenance road grading, repair and preventative maintenance
- Trash removal and debris removal along access roads and in the channel

5.1.5. Upper Calera Creek Element 2

The channel in this reach upstream to Highway 680 is narrow and relatively steep and there are little signs of any sediment accumulation although there are signs of some bank erosion that may require future stabilization work.

The District has conducted periodic maintenance activities along this reach of Calera Creek that includes:

- Erosion repair and preventative maintenance
- Trash removal and debris removal along access roads and in the channel

Upstream of Highway 680, the channel is not within District right-of-way although they do have an access road easement adjacent to the west bank. No maintenance in this reach has been performed and none is anticipated at this time unless erosion causes potential problems in the channel.

5.2. Continuing Project Maintenance Activities

This section presents the criteria for continuing project maintenance for the staff-recommended alternative described in Chapter 4 and an analysis of each project element that identifies changes anticipated from current maintenance.

5.2.1. Continuing Maintenance Criteria

Sediment Maintenance: The conditions to trigger sediment maintenance activity would be when the accumulation of sediment results in a 50 percent reduction in design freeboard, as determined by hydraulic analysis. Sediment removal along Lower Berryessa Creek is planned to continue in accordance with current regulatory approvals.

Vegetation Maintenance: The following vegetation maintenance would be performed on an annual cycle:

> ***Levees:*** Prevent vegetation growth along top of levee maintenance roads, prevent woody and shrub vegetation establishment and growth on levee slopes or top. Continue current vegetation control by mowing and spraying. Future woody growth removal will require hand removal.

Floodwalls: Maintain adjacent ROW on outside face of walls clear of weeds and trash. Remove woody vegetation from within 5 feet of the inside face of walls, except where such vegetation is intended to be allowed to grow.

Natural and Low-flow Channels: Monitor for hazardous tree conditions, channel blockages and other conditions that would impede flow or create local drainage problems. Continue current vegetation (cattails) control practices in wetlands by spraying.

Riparian Plantings: Any potential riparian plantings on the vegetated bench would be left as natural as possible with no required regular maintenance. Hazardous trees would be removed and replaced as needed. Vegetated bench slope failures would be identified as early as possible and repaired as needed.

Structural Maintenance: The following structural maintenance would be performed on an annual cycle (unless otherwise noted):

Levees: Levee tops and slopes would be monitored for erosion damage and repaired as needed. Continue current rodent control by trapping. Every five years, top-of-levee elevations would be monitored and restored to design elevations if measured elevations differed from design elevations by more than 6 inches.

Floodwalls: Floodwalls would be visually monitored for cracks, spalls and other types of damage and repaired as needed. Every five years, floodwall elevations would be monitored through surveying identified control points. If measured elevations vary from the as-built elevations by more than 4 inches, the floodwalls would be analyzed by a competent structural engineer for foundation problems. Top-of-wall elevations would be restored to design elevations if measured elevations differ from design elevations by more than 6 inches.

Maintenance Access Roads: Asphalt-paved, concrete-paved and soil-cement roads would be monitored for cracking and potholes and repaired as needed. Aggregate base roads would be monitored for erosion and potholes and repaired as needed and measures taken to prevent vegetation growth.

Concrete Channels: Exposed and accessible channel walls would be visually monitored for cracks, spalls and other types of damages and repaired as needed. Inlet and outlet structures would be monitored and maintenance activity would be triggered if any erosion damage, structural damage, or sediment depths greater than 1 foot above design conditions were observed.

5.2.2. Lower Berryessa Creek

Ongoing Maintenance: The staff-recommended alternative is not anticipated to cause any significant changes to the sediment flow through most of the existing channel and it is expected that the current sediment removal schedule of one half of the channel each year will continue. Levee and access road maintenance is expected to decrease from current conditions due to the improved and more durable materials used to construct the new roads and levees. Vegetation and rodent control effort for levees will be reduced, as one of the existing levees would be eliminated and replaced by a floodwall. Other current maintenance activities including low-flow channel maintenance, trash removal and fence repair are not anticipated to change.

New Project Elements: New project components of the staff-recommended alternative requiring continuing maintenance include the floodwalls and potential riparian planting areas.

Floodwall surfaces are susceptible to graffiti which will require additional maintenance effort for monitoring, prevention and removal. It is anticipated that costs for graffiti removal may rise substantially over current costs. The maintenance effort required to monitor for and repair cracks and other damage to the walls is expected to be limited until the nearing of the end of the design life (usually 30 to 50 years).

Additional maintenance may also be required for removal of trash from the narrow (approximately 5 foot wide) space between the outside face of the walls and the existing ROW. While the materials proposed for backfill in this space (controlled low-strength material) will prevent vegetation growth, access to this space will be limited, making trash removal more difficult than current conditions.

If riparian plantings are installed along the vegetated bench, they will require periodic monitoring and occasional maintenance. While the frequency of maintenance is expected to be low, it is likely to require selective, hand-clearing methods in areas with limited access for vehicles and equipment.

5.2.3. Tularcitos Creek

Ongoing Maintenance: The staff-recommended alternative is not anticipated to cause any significant changes to the sediment flow through most of the existing channel and it is expected that the current periodic sediment removal will continue. The downstream end of the channel near the pump station wet well is expected to accumulate sediment that may require annual removal. Other current maintenance activities are not expected to change.

New Project Elements: New project components requiring continuing maintenance include floodwalls and the pump station. The pump station will require significant regular (annual, unless otherwise noted) maintenance for reliable operation, including:

- Remove sediment in the wet well, outlet structure and outlet channel.

- Monitor building finishes and fixtures, repair as needed
- Test and exercise pump station equipment, monthly cycle.
- Service pumps, engines, gears and linkages in accordance with manufacturers' recommended maintenance schedule

The floodwalls will require additional effort for monitoring, repair and especially graffiti removal as identified for Lower Berryessa Creek. However, the limited access for trash removal outside the floodwall described for Lower Berryessa Creek would not occur on Tularcitos Creek.

5.2.4. Lower Calera Creek

Ongoing Maintenance: The staff-recommended alternative is not anticipated to cause any significant changes to the sediment flow through most of the existing channel and it is expected that the current periodic sediment removal will continue. Other current maintenance activities are not expected to change.

New Project Elements: New project components requiring continuing maintenance include the floodwalls and riparian planting areas. The additional maintenance anticipated for these components is as described for Tularcitos Creek and Lower Berryessa Creek, respectively.

5.2.5. Upper Calera Creek Element 1

Ongoing Maintenance: The staff-recommended alternative is not anticipated to cause any significant changes to the sediment flow through most of the existing channel and it is expected that the current periodic sediment removal will continue. Other current maintenance activities are not expected to change.

New Project Elements: The only significant new project elements requiring continuing maintenance are the floodwalls. The additional maintenance anticipated for the floodwalls is as described for Tularcitos Creek.

5.2.6. Upper Calera Creek Element 2

Ongoing Maintenance: The staff-recommended alternative is not anticipated to cause any significant changes to the sediment flow through most of the existing channel and it is expected that the current periodic sediment removal will continue. Other current maintenance activities are not expected to change.

New Project Elements: The only significant new project elements requiring continuing maintenance is the bypass channel. Flows in the new bypass channels will occur infrequently, but sediment is expected to accumulate in the channel over time. This sediment will need to be periodically removed to preserve bypass channel capacity.

5.3. Maintenance Cost

The estimated additional annual maintenance costs for the staff-recommended alternative, are summarized in Table 5-3 for each project element. Total additional maintenance costs for the staff-recommended alternatives is $168,000 per year. Approximately 33 percent of the additional estimated maintenance costs are associated with the pump station equipment for the Tularcitos Creek project element.

Table 5-3: Lower Berryessa Creek Project – Estimated Additional Maintenance Costs

Project Element	Annual Additional Maintenance Cost (Estimated)	Notes
LOWER BERRYESSA CREEK		
Sediment Maintenance	$ -	No significant change anticipated
Vegetation Maintenance	$62,000	Estimated for potential riparian plantings. Limited maintenance by maintenance crew with light equipment, approx 60 working days/year
Levees	($22,000)	Reduced maintenance costs due to elimination of one levee and more durable materials used for reconstructed levee. Savings estimated from elimination of spraying, mowing and rodent control for one levee.
Floodwalls	$13,000	Graffiti removal cost estimate based on 2-person crew, 1 day/month.
Maintenance Access Roads	$ -	No additional maintenance costs due to more durable materials than existing roads.
Subtotal	**$53,000**	
TULARCITOS CREEK		
Sediment Maintenance	$24,000	Sediment removal from channel at pump station by maintenance crew with light equipment, approx 5 working days per year
Vegetation Maintenance	$ -	No significant change anticipated
Floodwalls	$10,000	Graffiti removal cost estimate based on 2-person crew, 0.5 days/month.
Maintenance Access Roads	$ -	No additional maintenance costs assumed over current.
Pump Station		
Wet well, inlet and outlet	$24,000	Sediment removal from wet well, inlet and outlet by maintenance crew with light equipment, approx 5 working days per year.
Building	$18,000	Basic maintenance of building finishes and fixtures estimated based on 2-persons skilled labor crew, 10 working days/year.
Equipment	$30,000	Test and exercise pumps monthly by 2-person skilled crew, plus 10 working days/year to service equipment, plus maintenance parts and supplies.
Subtotal	**$70,500**	

Project Element	Annual Additional Maintenance Cost (Estimated)	Notes
LOWER CALERA CREEK		
Sediment Maintenance	$ -	No significant change anticipated
Vegetation Maintenance	$15,500	Limited maintenance by maintenance crew with light equipment, approx 15 working days/year
Floodwalls	$10,000	Graffiti removal cost estimate based on 2-person crew, 0.5 days/month.
Maintenance Access Roads	$ -	No additional maintenance costs assumed over current.
Subtotal	**$22,000**	
UPPER CALERA CREEK ELEMENT 1		
Sediment Maintenance	$ -	No significant change anticipated
Vegetation Maintenance	$ -	No significant change anticipated
Floodwalls	$10,000	Graffiti removal cost estimate based on 2-person crew, 0.5 days/month.
Maintenance Access Roads	$ -	No additional maintenance costs over current.
Subtotal	**$6,500**	
UPPER CALERA CREEK ELEMENT 2		
Sediment Maintenance	$ -	No significant change anticipated
Vegetation Maintenance	$ -	No significant change anticipated
Bypass Channel	$35,000 - $40,000	Assume sediment removal by maintenance crew with light equipment 10 working days every 2 years.
Subtotal	**$16,000**	
PROJECT TOTAL	**$168,000**	

CHAPTER 6. PROJECT COST, FUNDING AND SCHEDULE

CHAPTER 6 PROJECT COST, FUNDING AND SCHEDULE

6.1 Project Cost

The overall capital cost for the staff-recommended would be $48.5 million in 2009 dollars, including design, construction, and contingencies.

The capital design/construction estimate is summarized below in Table 6.1. The detailed cost estimate is provided in Appendix E. Estimated costs are for the purpose of providing guidance to assist in establishing budgets for the Project and are based on professional judgment and experience. Actual costs may vary from those estimated due to availability of labor, equipment or materials, market conditions and changes that may occur during design.

Table 6-1: Summary of Estimated Design and Construction Costs

Project Element	Design & Construction Cost ($ millions, 2009)[1]
Lower Berryessa Creek	27.2
Tularcitos Creek	15.0
Lower Calera Creek	3.3
Upper Calera Creek Element 1	1.0
Upper Calera Creek Element 2	2.0
TOTAL	48.5

[1] Cost estimate detail sheets included in Appendix E

6.2 Project Funding

The proposed Project would be funded by the Watershed and Stream Stewardship Fund.

6.3 Project Schedule

The main constraint on the schedule for the Project is that construction of proposed improvements for the Lower Berryessa Creek, Tularcitos Creek and Lower Calera Creek project elements must be completed and operational before completion of improvements for the upstream Upper Berryessa Creek Project. Construction of the Upper Berryessa Creek Project is scheduled to be completed in 2015 at the time this report was being prepared.

The Project is split into three phases, based on the nature of improvements and their relationship to each other and the Upper Berryessa Creek Project.

Phase 1

This phase would consist of the design and construction of the Lower Berryessa Creek and Lower Calera Creek project elements. Construction of these elements must be completed prior to completion of the Upper Berryessa Creek Project.

Phase 2

This phase would consist of design and construction of the Tularcitos Creek project element. Construction of this element must be completed prior to completion of the Upper Berryessa Creek Project.

Phase 3

This phase would consist of design and construction of Upper Calera Creek Element 1 and Upper Calera Creek Element 2. Construction of these elements would not be affected by the Upper Berryessa Creek Project.

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions and Recommendations

The existing capacities of Lower Berryessa Creek, Tularcitos Creek and Calera Creek are not adequate to contain the peak design flows when future upstream channel improvements on Berryessa Creek are taken into account. If flood protection is not improved, properties near these creeks in the City of Milpitas could be flooded by flows as low as about half the peak design flow (between a 10-year and a 25-year flood event). In addition, large sections of the existing levees along Lower Berryessa Creek are constructed with highly plastic clays that are subject to excessive shrinkage and swelling, which has caused erosion and cracking of the levees. Continued cracking and slope erosion would undermine levee stability, which could cause some sections of the levee to fail.

The staff-recommended alternative would protect the community from the design flood and accomplish the District's Natural Flood Protection objectives. The staff-recommended alternative would result in the following benefits:

Flood Protection: The staff-recommended alternative would protect public and private properties along the three creeks from the modified 100-year design flows, developed by the District and Corps of Engineers, for the watershed.

Maintenance: The staff-recommended alternative would improve maintenance access to Lower Berryessa Creek and portions of Calera Creek.

Trail System: The design of the staff-recommended alternative is integrated with the City of Milpitas trail system and would provide opportunities for enhanced trail access and amenities.

Habitat Enhancements: The staff-recommended alternative provides opportunities for improved stream habitat conditions with the potential for new riparian vegetation along Lower Berryessa Creek and portions of Calera Creek that will be left as undisturbed and as natural as is feasible.

The staff-recommended alternative meets all the specific Project objectives and balances the Natural Flood Protection objectives and objectives identified by the City of Milpitas better than all the other alternatives considered. Therefore, it is recommended that the proposed project be approved and detailed plans and specifications developed for its construction.

APPENDIX A - EXISTING CONDITIONS TECHNICAL MEMORANDUM

CHANNEL & BASIN HISTORY REPORT
AUGUST 30, 2001

BERRYESSA CREEK LEVEES PROJECT
CHANNEL & BASIN HISTORY REPORT

1 INTRODUCTION

This report regarding Berryessa Creek channel and basin history is divided into five parts. The first part provides a brief overview of the geologic and geomorphic setting of the Berryessa Creek basin. The second part provides a detailed description of the project reach, which is located between Calaveras Boulevard and Lower Penitencia Creek. The third part examines the historical evolution of Berryessa Creek, including changes in channel planform, bed profile, and cross section. Part four briefly reviews available sediment yield information for the Berryessa Creek basin and part five discusses future geomorphic trends for the project reach.

Information for this geomorphic investigation was obtained from several key sources, including the Santa Clara Valley Water District (District), the U.S. Army Corps of Engineers (Corps), and the library systems of the University of California, California State University, and the California State Library. In addition, journal article databases covering publications in water resources and engineering were searched for information related to Berryessa Creek and its regional setting. A list of reviewed documents is provided in the References section. A list of historical aerial photographs collected for the geomorphic study is shown in Table 1, and a list of historical topographic maps used for this task is shown in Table 2. In addition to the collection of reports, plans, maps, and aerial photographs, a site visit was conducted in April 2001.

2 PHYSIOGRAPHY

The Berryessa Creek watershed covers a 22.4 square mile area and is located on the eastern side of the Santa Clara Valley near Milpitas, California (Figure 1). Approximately 75% of the watershed covers upland, mountainous areas whereas 25% is located in the Santa Clara Valley. Monument Peak, at 2,594 feet, is the highest point in the Berryessa Creek basin and the lowest point is 3 feet at the confluence with Lower Penitencia Creek. Mean annual precipitation in the basin is 14.4 inches. There are no major reservoirs in the Berryessa Creek watershed.

Berryessa Creek flows west into the Santa Clara Valley then turns and flows northwest in an artificially constructed channel until it reaches its terminus at the confluence with Lower Penitencia Creek. Major tributaries to Berryessa Creek are Sweigert, Crosley, Sierra, Piedmont, Tularcitos, and Calera Creeks and Arroyo de Los Coches. The downstream 3,500 feet of Berryessa Creek is tidally influenced from the confluence with Lower Penitencia Creek to North Abel Street. Tidal action affects flow hydraulics in the lower part of the project reach.

The geology of the Berryessa Creek watershed consists mainly of Tertiary and Quaternary age sedimentary rocks in mountainous areas and semi-consolidated to unconsolidated Quaternary age sediments in the Santa Clara Valley. Tertiary age rocks range from 66.4 million to 1.6 million years old whereas Quaternary age rocks are 1.6 million years old and younger. Rocks in the mountainous part of the basin are mainly composed of marine and nonmarine sandstone, siltstone, and shale (Wagner et al., 1990). Minor tuff, claystone and partially to completely serpentinized ultramafic rocks outcrop in the basin at a few locations. Geology in the Santa Clara Valley portion of the watershed is limited to Quaternary age, semi-consolidated alluvium near the base of Los Buellis Hills and younger, unconsolidated alluvium further downslope. Alluvial sediments are

largely medium to fine-grained, consisting primarily of moderately to poorly sorted fine sand, silt, and clay.

Faulting in the Berryessa Creek watershed trends in a northwest - southeast orientation that follows the structural alignment of the Coast Range. Major faults in the basin include the Hayward Fault Zone and the Calaveras Fault (Jennings, 1994). Both faults are seismically active and have experienced numerous large earthquakes (M>5) in the historical record (Toppozada et al., 2000). Future large earthquakes along both faults are expected (Working Group on California Earthquake Probabilities, 1990; Toppozada et al., 2000). In addition to these major faults, numerous smaller faults cross through the Berryessa Creek watershed, all of them in a northwest - southeast orientation. Future large earthquakes in the vicinity of Berryessa Creek would likely increase landslide activity in the watershed, potentially increasing basin sediment yield. In a severe earthquake, or if a moderate earthquake occurred following heavy rainfall, landslide activity in the watershed could increase dramatically.

Landslides in mountainous areas of the Berryessa Creek basin are common. In a state wide survey of landslide activity, Radbruch and Crowther (1973) classified the Berryessa Creek basin as a type 4 area on a scale of 1 to 6, where a 6 indicates the highest landsliding activity. A prominent geomorphic feature of the upland basin is the unstable "canyon" reach of Berryessa Creek extending from about 1,500 feet to 4,000 feet upstream of Old Piedmont Road. This reach, which appears to lie within the Hayward-Crosley fault zone, is characterized by a very steep longitudinal profile, unstable steep bare side slopes and active landslide scarps. The underlying bedrock is composed of poorly consolidated, highly fractured Tertiary age rocks that contain swelling clays. This zone provides a plentiful supply of sediment to the creek channel, which is tightly confined by encroaching slide material. According to Brown and Jackson (1973), sediment yields from such areas are among the highest in the San Francisco Bay region.

The Santa Clara Valley experienced substantial land subsidence due to groundwater overdraft from approximately 1900 to 1965, the year that state water deliveries began to arrive in the San Jose area. Measured land subsidence recorded in downtown San Jose at the corner of North 1st Street and St. James Street was 14.1 feet from 1906 to 1995, with 13.0 feet (92% of total) occurring before 1966 (District, 1995). Berryessa Creek is located in the outer margin of the zone affected by land subsidence and experienced between 0 and 4 feet of subsidence from 1900 to 1967 (Poland and Ireland, 1988; District, 1995).

3 PROJECT AREA

3.1 Overview

The project reach is approximately 1.7 miles in length and located along Berryessa Creek from the Lower Penitencia Creek confluence to Calaveras Boulevard. The project reach is a manmade channel that was constructed in its current location by the District in 1976. Located in an urbanized area, the project reach is leveed and exhibits a uniform compound trapezoidal cross section with maintenance roads on either side of a low flow channel. Two areas in the project reach are concrete lined, a 700 foot length where the channel makes two 90 degree turns immediately upstream and downstream of the railroad bridges, and a 210 foot length at the Tularcitos Creek confluence. Both concrete lined channel lengths exhibit a simple trapezoidal channel cross section with no maintenance roads.

A total of six bridges cross the creek within the project reach. In downstream order they are: Calaveras Boulevard, North Hillview Drive, North Milpitas Boulevard, two adjacent railroad bridges, and North Abel Street. Calaveras Boulevard and the two railroad bridges significantly impede flood flows. The other bridges are either at or above the levee top elevation and do not significantly affect flow conveyance. Both the Calaveras Boulevard bridge and the railroad bridge openings are partially blocked with sediment and vegetation.

There are very few areas of bank protection in the project reach. Approximately 70 feet of rock bank protection is located opposite three culverts draining Hidden Lakes, which is about 1,500 feet upstream of the parallel railroad bridges. Rock bank protection is also located on both banks on the upstream side of Calaveras Boulevard bridge and some of the rocks have been dislodged due to bank erosion. Sacked concrete bank protection was observed on the left bank of Berryessa Creek at the confluence with Lower Penitencia Creek. There are very few trees in the project reach. Grasses, tules, and low shrubs are typical vegetation for most areas. None of the riparian vegetation provides significant shading to the creek channel.

3.2 Project Reach Geomorphology

The project reach is located in an actively aggrading section of Berryessa Creek (District, 1997; Ortiz, pers. comm.; District, 2001). During high flows, sediment deposits throughout the project reach, raising the channel bed elevation and decreasing channel flow conveyance capacity. Downstream of the railroad bridges sedimentation also occurs due to tidal action. As a result, regular maintenance by the District is required to remove sediment and maintain channel capacity.

Sedimentation in the downstream portion of the project reach is influenced by tidal action. The mean higher high tide occurs at an elevation of 7.4 feet (NAVD 88), based on tide gage data from Coyote Creek at Alviso. The gage is located approximately 5.5 miles northwest of the project reach. This elevation intersects the Berryessa Creek channel invert approximately 1,000 feet upstream of the parallel railroad bridges.

Recent sedimentation in the reach from Calaveras Boulevard to North Hillview Drive was apparent during the April 2001 site visit in the form of recently deposited, unvegetated sand and gravel bars. Recent sediment deposits on unvegetated bars further downstream were more fine-grained, consisting primarily of sand and silt. Overall, very few unvegetated bars are present in the project reach. In most cases, areas adjacent to the low flow channel are vegetated with tules or grasses; however, these areas can become largely unvegetated following sediment deposition during floods or sediment removal by the District. Because the low flow channel is confined within a 40 to 50 foot wide channel bottom, significant channel meandering and bar development is restricted. In addition, ongoing sediment deposition and subsequent maintenance activities to remove sediment result in frequent alteration of the low flow channel alignment, preventing the development of regular stream meanders.

Through the project reach the channel invert slope varies between distinct sub-reaches that display uniform slopes (Figure 2). There are three distinct sub-reaches within the project reach. The downstream sub-reach extends from the downstream end of the project to approximately 1,000 feet downstream of the railroad bridges. The average slope of the downstream sub-reach is 0.0001 $^{feet}/_{feet}$. The middle sub-reach extends from approximately 1,000 feet downstream of the railroad bridges to approximately 1,000 feet upstream of Milpitas Boulevard. The middle sub-reach has an average bed slope of 0.0012 $^{feet}/_{feet}$. The upstream sub-reach, with an average bed slope of 0.0032 $^{ft}/_{ft}$, includes the remaining portion of the project reach, extending upstream to Calaveras Boulevard. A short distance of localized steeper than average bed slope of approximately 0.05 $^{feet}/_{feet}$ in the upstream sub-reach occurs at the concrete lined channel immediately downstream of the Hetch Hetchy pipeline crossing. The existing bed slopes in the middle and upstream sub-reaches are relatively the same as the channel bed slopes shown on the plans for the 1976 project that constructed the present alignment of Berryessa Creek. The existing bed slope in the downstream sub-reach is significantly flatter than the slope shown on the construction plans for the same location.

The sub-reaches, as identified by unique bed slopes, roughly correspond to the locations where different types of sediment deposits were observed. Gravel and sand were observed on the channel bed and bars in the upstream sub-reach, which is where the steepest bed slope occurs. Silts, that are primarily deposited by tidal activity, were observed as the main bed material in the downstream sub-reach. The middle sub-reach is a

transitional zone with primarily sand and some gravel observed at the upstream end, and mostly silt observed as the bed material at the downstream end.

4 HISTORICAL GEOMORPHOLOGY

The objective of this portion of the report is to document the historical evolution of Berryessa Creek from available maps, aerial photographs, and documents. Specific attention is paid to documenting changes in channel planform, bed profile, cross section geometry, as well as historical flooding, maintenance, and channel improvements. Historical maps, aerial photographs, and documents reviewed for this portion of the report are listed in Tables 1 and 2 and in the References section, respectively.

4.1 Historical Channel Planform (1866 - present)

The alignment of Berryessa Creek has undergone very significant changes since the middle of the 19th century (Figure 3). Most of these changes resulted from human activities, including channel confinement and channel realignment to divert flood flows away from agricultural and urban areas. Prior to these modifications, Berryessa Creek exited the Los Buellis Hills and flowed out onto an alluvial fan. Alluvial fans are defined as outspread, sloping masses of alluvium deposited by streams (Bates and Jackson, 1984). They are typically located in arid or semi-arid regions.

Alluvial fans typically form when a stream with a high sediment load exits a steep, mountainous area and flows into a more gradually sloping valley. The decline in slope causes sediment to deposit in the creek during flood flows, resulting in a decrease in channel capacity with distance downstream. As channel capacity declines, flood flows break out of the main channel and spread out onto the unconfined alluvial fan surface, causing flooding and sediment deposition over large areas. Although all of the alluvial fan is formed by sediment deposition from stream flows, only part of the fan is active at any given time. Channel avulsion will usually change the area of active fan building from one part of the fan to another over time. This generally occurs when the majority of flood flows shift into a distributary channel and the main channel is abandoned. The abrupt change in channel alignment from 1866-79 to 1899 in Figure 3 may have been due to channel avulsion. The 1899 channel planform also shows three arrows emerging from the downstream end of Berryessa Creek. These arrows were present in 1899 mapping and identify the transition from a single creek channel to the distributary flow pattern characteristic of alluvial fan systems.

By 1943, Berryessa Creek extended much further downstream, reaching as far as Lower Penitencia Creek (Figure 3). Examination of historical aerial photographs shows orchards along the creek during this period. Given the relatively short length of Berryessa Creek in 1866-79 and in 1899, it is likely that the creek had been lengthened by human activity prior to 1943 to either divert flood flows away from orchard areas, provide flood control, or supply irrigation water. Regional land subsidence that occurred throughout Santa Clara Valley may also have played a role in increasing stream length. Although the amount of land subsidence that had occurred in the Milpitas area by 1943 cannot be determined exactly, it can be inferred from other data that between 0 and 3 feet of subsidence occurred in the vicinity of Berryessa Creek by 1943 (Poland and Ireland, 1988; District, 1995). Land subsidence increased with distance toward the central Santa Clara Valley. Thus, Berryessa Creek experienced very little land subsidence near the foothills and the greatest amount of subsidence in the lower part of the creek. Land subsidence affects area streams by creating a drop in base level, causing the streams to become steeper. This results in an increase in stream energy and subsequent channel degradation as streams adjust to a new base level. In the case of alluvial fan systems, this would result in an overall lengthening of the stream channel.

Major changes in channel alignment from 1943 to 1980 in Figure 3 were caused by human modifications to Berryessa Creek for flood control purposes, mainly for the protection of growing residential and light

industrial areas that had largely replaced orchards by the 1970's. The most significant modification to Berryessa Creek occurred between 1953 and 1961 when the creek was realigned to flow northward. As a result, by 1961 the confluence of Berryessa Creek with Lower Penitencia Creek was shifted more than 2 miles downstream. Channel realignment observed in the project reach between 1961 and 1980 occurred in 1976 as part of a District flood control program. The 1980 channel alignment in Figure 3 reflects the current configuration of Berryessa Creek.

Channel realignment is also observed on tributaries of Berryessa Creek. 1899 mapping shows no tributaries to Berryessa Creek in Santa Clara Valley. Instead, Sweigert, Crosley, Sierra, and Piedmont Creeks flow downslope and terminate less than a half mile downstream of the border between Santa Clara Valley and the Los Buellis Hills. Each creek shows three arrows emerging from its downstream end, indicative of the distributary channel pattern associated with an alluvial fan. By 1980, Sweigert, Crosley, Sierra, and Piedmont Creeks have been lengthened and realigned to flow into Berryessa Creek (Figure 1). Other major tributaries to Berryessa Creek, namely Calera Creek and Arroyo de los Coches, extended downstream to Lower Penitencia Creek in 1899 mapping. Today, these creeks are intercepted by the existing Berryessa Creek alignment.

When compared to early maps from the late 1800's, the present Berryessa Creek alluvial fan surface appears very different. Land use on the fan is almost entirely urbanized and all but the largest flood flows are now confined to the Berryessa Creek channel. Natural alluvial fan building processes have ceased. Instead, most flood flows are now confined to the creek channel and conveyed downstream to Coyote Creek.

4.2 Historical Channel Bed Profile and Cross Sections

Historical channel bed profile data were available for the project reach from 1976 District as-built plans. These data are compared with 1997 survey data collected by Nolte Associates (1999) and 2001 survey data collected by Winzler & Kelly (2001) in Figure 4. Examination of Figure 4 shows some minor changes, less than 2 feet, in bed elevation through the project reach from 1976 to 2001. The minor changes include both aggradation and degradation.

Changes in channel bed elevation from 1976 to 2001 are primarily dependent on District sediment removal activities to restore channel capacity following sediment accumulation. If the District did not manually remove sediment from the channel, a general aggradational trend would be observed along the entire project reach.

River cross sections from 1976 and 2001 are shown in Figures 5 through 8. Cross sections from 1976 were obtained from as-built plans (District, 1976), 2001 cross sections were surveyed for this project. Different datums were used for the 1976 and 2001 cross section surveys. Data from 1976 are referenced to NGVD 29, whereas 2001 data are referenced to NAVD 88. The 1976 data was updated to NAVD 88 datum so that a direct comparison could be made between the 2001 cross section data and the 1976 data. Due to inconsistencies in local benchmark elevations, the correction factor that was used is approximate, and may be in error by up to 0.5 feet.

Examination of 1976 pre-project (existing) and as-built cross sections in Figures 5 through 8 shows that the 1976 project greatly increased channel flow capacity. In Figure 8 there is no existing channel because this part of Berryessa Creek was realigned during the 1976 project (Figure 3). The 1976 as-built channel cross section is very similar in Figures 5 through 8. Each cross section exhibits bordering levees with interior maintenance roads on either side of a low flow channel. This configuration is generally maintained from 1976 to 2001 although two trends are evident. First, the area between the maintenance roads in each cross section shows sediment accumulation from 1976 to 2001. This reflects the depositional nature of the project reach and shows where sedimentation has occurred since the last time sediment was removed by the District. Second, the area between the maintenance roads in 2001 exhibits a distinct low flow channel and adjacent bar

surfaces. In general, bar surfaces occupy about 2/3 of the area between the maintenance roads and the low flow channel about 1/3 of the area.

4.3 Historical Flooding

Detailed reports on flooding and flood related damages in Santa Clara County from 1982 to present were obtained from the District. Reports on flooding prior to 1982 were not available although other references identify historical flooding in Santa Clara County in 1899, 1911, 1931, 1937, 1940, 1941, 1950, 1952, 1955, 1958, 1962, 1963, 1968, 1973, and 1980 (District, 1982a). Later flooding in 1982, 1983, 1986, 1995, 1997, and 1998 is documented in District flood reports. Prepared immediately following each flood event, these flood reports provide flood maps, damage estimates, and rainfall and streamflow data from gages on streams affected by flooding.

A review of these flood reports indicates that flooding along Berryessa Creek occurred in 1982, 1983, and 1998. No flooding was reported on Berryessa Creek during the 1986, 1995, and 1997 floods in Santa Clara County. Flooding on Berryessa Creek in 1982 was minimal, affecting only a small area about 1,000 feet upstream of Calaveras Boulevard and causing no damage (District, 1982b). Widespread flooding, however, did occur immediately downstream of Berryessa Creek on both Lower Penitencia Creek and Coyote Creek. Flooding on Berryessa Creek in 1983 was much more damaging and widespread (District, 1983). The creek levees were overtopped at multiple locations, including upstream of Old Piedmont Road, upstream and downstream of Montague Expressway, and at the confluence of Berryessa Creek with both Piedmont Creek and Arroyo de Los Coches. Extensive flooding also occurred on Lower Penitencia Creek both upstream and downstream of the Berryessa Creek confluence. Flooding in 1998 occurred at the confluence of Berryessa Creek with Calera Creek (Schaaf & Wheeler, 1998). Flood damage was reported on several streets north of the confluence.

4.4 Historical Sediment Removal

Large quantities of sediment and debris have been removed from Berryessa Creek by District crews in an ongoing effort to maintain flow capacity in the channel. Sediment removal records for the project reach are shown in Table 3 and have been kept by the District since the project reach was re-aligned to its current location in 1976 (District, 1976). Although this discussion focuses on sediment removal from the project reach, sedimentation and channel aggradation are major and persistent problems throughout Berryessa Creek.

Examination of Table 3 shows that more than 165,000 cubic yards (yd^3) of sediment was removed from the project reach during the 1977 to 1999 period. Note that years in Table 3 represent fiscal years (FY) rather than calendar years. Thus, sediment reported as being removed in 1998 was removed sometime between July 1, 1997 and June 30, 1998. In addition, the fiscal year in which sediment was removed does not necessarily represent the fiscal year in which the sediment was initially deposited. For example, from FY 1993 to FY 1997 no sediment was removed from the project reach due to lack of permits (Ortiz, pers. comm.). Thus, the enormous quantity of sediment removed in FY 1998 represents the accumulation of sediment over a 4 to 5 year period.

The volume of sediment removed from the project reach each year is highly variable, ranging from as high as 33,040 yd^3 to no sediment removal. The average annual amount of sediment removed from the project reach during the period of record is approximately 7,500 yd^3 or 4,500 yd^3/mi/yr. When applied uniformly over the entire channel bed in the project reach, this sediment volume yields a reach average of 5 to 6 inches of sediment accumulation per year. Thus, large flood events which deposit sediment loads much higher than the average could result in more than 1 or 2 feet of sediment accumulation in some parts of the project reach. In contrast, dry years with no high flow would result in limited sedimentation, caused by both fluvial processes and by tidal action in the downstream end of the project reach.

Table 3 also identifies where sediment was removed from the project reach. District records report limits of sediment removal within the project reach in three ways: 1) the Lower Penitencia Creek confluence to the railroad bridges; 2) the railroad bridges to Calaveras Boulevard; or 3) Lower Penitentia Creek confluence to Calaveras Boulevard. Sediment volumes removed from these reported reaches amount to 37,266 yd^3, 34,692 yd^3, and 93,650 yd^3, respectively. The total volume of sediment removed in the project reach between 1980 and 1998 is 165,608 yd^3.

Given that the reach upstream of the railroad bridges is more than twice the length of the reach downstream, these data suggest that per lineal foot the rate of sediment accumulation downstream of the railroad bridges is about twice that of the reach upstream. This higher sedimentation rate is likely caused by inflowing sediment from daily tidal action.

5 PREVIOUS SEDIMENT YIELD ANALYSIS

Preliminary estimates of sediment yield for the Berryessa Creek watershed were compiled by **nhc** (1990). **nhc** reviewed available sediment yield information, including studies by the Corps and the Soil Conservation Service that used the Universal Soil Loss Equation (USLE). **nhc** also conducted sediment yield analyses of the Berryessa Creek watershed using the Pacific Southwest Inter-Agency Conference (PSIAC) method, the Dendy-Bolton method, comparison with data from Taylor (1983) and Flaxman (1972), and the analysis of suspended sediment data. Based on an examination of all available data, **nhc** (1990) developed the following estimates of mean annual sediment yield:

Berryessa Creek at Old Piedmont Road	=	9,900 tons
Sweigert, Crosley, and Sierra Creeks	=	1,900 tons
Piedmont Creek	=	700 tons
Arroyo de los Coches	=	3,200 tons

Sediment yield values for tributary streams are at their confluence with Berryessa Creek.

A sediment budget was also developed by **nhc** (1990) to estimate the amount of sediment from Berryessa Creek and its tributaries that may be transported to Calaveras Boulevard. The sediment budget analysis estimated the mean annual inflowing sediment load at Calaveras Boulevard to be 9,200 tons. Due to a lack of available data and numerous uncertainties and assumptions, the estimated sediment budget was considered to be tentative. Recommendations were made to collect periodic sediment load data in order to improve these preliminary estimates.

6 FUTURE TRENDS

Sediment accumulation and channel bed aggradation will continue to occur in the project reach. Sediment removal will be required on a regular basis to maintain channel flow capacity. Unless sediment transport of the creek is altered by a construction project that modifies the channel (e.g., installation of a sedimentation basin), sediment removal will continue to be required at the same rate that it presently is. Based on historical sediment removal quantities, the District has estimated that an average of 7,500 yd^3 of sediment will need to be removed annually from the project reach. The volume that must be removed for any single year, specifically following a significant flooding event, may be as much as five times greater than the average volume.

Stream bank erosion is largely absent from the project reach, a condition that is expected to continue into the future. The lack of significant bank erosion, other than that observed downstream of Tularcitos Creek, is due

primarily to the depositional nature of the project reach, channel maintenance activities, and to cohesive bank sediments that are resistant to erosion. The depositional nature of the project reach results in a channel morphology characterized by an aggrading channel bed and depositional bar features on stream banks rather than by erosional features. In addition, ongoing maintenance activities to remove sediment result in frequent alteration of the low flow channel and adjacent bar surfaces. This prevents the development of regular point bars and stream meanders that could cause erosion on the outer bank of meander bends. Bank erosion that does occur will likely proceed at a very slow rate due to the predominantly cohesive bank sediments found in the project reach. These sediments consist primarily of silty clay and are resistant to bank erosion (USACE, 1987). The future occurrence of subsidence in the project reach could potentially lead to channel bed and bank erosion but the return of subsidence in the area is deemed highly unlikely by the District.

Due to ongoing sediment accumulation in the project reach, frequent sediment removal by District crews is needed to maintain channel flow capacity. As a result, long-term changes in low flow channel planform, invert profile, and cross section geometry will be almost entirely due to sediment removal practices rather than natural stream processes.

Opportunities that use geomorphic methods to restore channel equilibrium and reduce the amount of sediment removal required in the project reach are nonexistent. A natural channel equilibrium for Berryessa Creek consists of an alluvial fan system with a channel alignment similar to that observed in the 1800's (Figure 3). In the vicinity of the project reach and under natural conditions, the Berryessa Creek channel would not exist. Because Berryessa Creek has been confined, leveed, and re-aligned, the creek no longer exhibits a channel morphology consistent with that of an alluvial fan. Instead, the alluvial fan processes are confined into a linear feature. Sedimentation that would occur during floods over large areas of the alluvial fan are now restricted to the creek channel, resulting in the need for regular annual maintenance and sediment removal. This characteristic greatly reduces opportunities to establish stable low flow channel features that will not be periodically disturbed by required maintenance.

7 SUMMARY AND CONCLUSIONS

The following conclusions summarize the findings of this geomorphic investigation:

- Regional geology, mountainous topography, climate, and seismic activity contribute to high sediment production in the Berryessa Creek basin.

- Historically, Berryessa Creek exited the Los Buellis Hills and flowed out onto an unconfined alluvial fan. Alluvial fans exhibit a distributary channel pattern where flood flows spread out with distance downstream, causing shallow flooding and sediment deposition over large areas.

- Since the mid 1800's Berryessa Creek has been lengthened, confined by levees, and re-aligned. Patterns of sediment deposition that historically occurred on the alluvial fan are now confined to the creek channel, causing stream aggradation.

- Sediment deposition and stream bed aggradation is a persistent problem in Berryessa Creek, particularly in the project reach. More than 165,000 yd^3 of sediment was removed from the project reach between 1977 and 1999. On average, approximately 7,500 yd^3 (4,500 yd^3/mi) of sediment is removed from the project reach each year.

- The downstream 4,000 feet of the project reach is tidally influenced. Tidal action will contribute to the daily accumulation of tidal borne sediment in the lower portion of the project reach.

- Based on sediment removal records from the District, the rate of sediment accumulation in the reach downstream of the railroad bridges is about twice that of the reach upstream.

- The project reach has exhibited little change in invert profile or cross section since it was constructed. This can be directly attributed to sediment accumulation followed by regular sediment removal by District crews. As a result, future changes to the channel bed profile and cross section geometry in the project reach will be largely due to sediment removal practices rather than natural stream processes.

- **nhc** (1990) estimated a mean annual inflowing sediment load of 9,200 yd^3 for Berryessa Creek at Calaveras Blvd. The estimated sediment load was considered to be tentative due to a lack of data, uncertainties, and several assumptions. Inflowing sediment load measurements are necessary to improve these estimates and reduce their uncertainty.

REFERENCES:

Bates, R.L. and Jackson, J.A.(eds.), 1984. Dictionary of Geological Terms. Third Edition, Doubleday, 571 pp.

Brown, W.M. and Jackson Jr., L.E. 1973. Erosional and depositional provinces and sediment transport in the south and central part of the San Francisco Bay Region, California. U.S. Geological Survey, Miscellaneous Field Studies Map MF-515.

Flaxman, E.M. 1972. Predicting sediment yield in the western United States. ASCE hydraulics Div. Journal, December, pp. 2073-2085.

Jennings, C.W., 1994. Fault activity map of California and adjacent areas with locations and ages of recent volcanic eruptions. California Division of Mines and Geology, Geologic Data Map No. 6, Scale 1:750,000.

Nolte Associates, Inc., 1999. LOMR application for Berryessa Creek. City of Milpitas, Santa Clara County, California.

Northwest Hydraulic Consultants, Inc., 1990. Sediment engineering investigation and preliminary hydraulic design of the Berryessa Creek flood-control project. For U.S. Army Corps of Engineers, Sacramento District, 29 pp.

Ortiz, Jose, personal communication. Coyote, Uvas / Llagas Watershed Support Manager. Santa Clara Valley Water District, 5750 Almaden Expressway, San Jose, CA, 95118.

Poland, J.F. and Ireland, R.L., 1988. Land subsidence in the Santa Clara Valley, California, as of 1982. U.S. Geological Survey Professional Paper 497-F, 61 pp.

Radbruch, D.H. and Crowther, K.C., 1973. Map showing areas of estimated relative amounts of landslides in California. U.S. Geological Survey, Miscellaneous Geologic Map Investigations Map I-747, Scale 1:1,000,000.

Santa Clara Valley Water District, 1976. Map and construction plan for Berryessa Creek from lower Penitencia Creek to Calaveras Blvd. in the city of Milpitas, California. Project No. 4017, 46 sheets.

Santa Clara Valley Water District, 1982a. Lower Penitencia Creek planning study (Coyote Creek to Montague Expressway). Engineer's report and negative declaration. November, 60 pp.

Santa Clara Valley Water District, 1982b. Report on flooding and flood related damages, Santa Clara County, January 1 to April 30, 1982. 20 pp.

Santa Clara Valley Water District, 1983. Report on flooding and flood related damages, Santa Clara County, January 1 to April 30, 1983. 21 pp.

Santa Clara Valley Water District, 1995. Depth to water, land subsidence, population. informational color chart.

Santa Clara Valley Water District, 1997. Urgent sediment removal projects. Clearances from U.S. Army Corps of Engineers, Regional Water Quality Control Board, California Department of Fish and Game Addendum to MOU, Fish and Wildlife Service, and BMP's.

Santa Clara Valley Water District, 2001. SCVWD Sediment Removal Records - All Flood Control Facilities 1977 to 1998. Excel spreadsheet.

Schaaf & Wheeler Consulting Engineers, 1998. California landing flooding, February 3, 1998, flooding evaluation study, prepared for City of Milpitas and Santa Clara Valley Water District, 29 pp.

Taylor, B.D. 1983. Sediment yield in coastal southern California. ASCE Journal of Hydraulic Engineering, June, pp. 71-85.

Toppozada, T., D. Branum, M. Petersen, C. Hallstrom, C. Cramer, and M. Reichle, 2000. Epicenters of and areas damaged by M>5 California earthquakes, 1800-1999. California Division of Mines and Geology, Map Sheet 49.

USACE (U.S. Army Corps of Engineers), 1987. Coyote Creek and Berryessa Creek interim feasibility report and final environmental impact statement, Guadalupe River and adjacent streams investigation, Santa Clara County, California. San Francisco District, 197 pp.

Wagner, D.L., E.J. Bortugno and R.D. McJunkin, 1990. Geologic map of the San Francisco-San Jose Quadrangle. California Division of Mines and Geology, Map No. 5A (Geology), Scale 1:250,000.

Winzler & Kelly, 2001. Project survey data

Working Group on California Earthquake Probabilities, 1990. Probabilities of large earthquakes in the San Francisco Bay region, California. U.S. Geological Survey, Circular 1053, 51 pp.

LIST OF TABLES

Table 1. Historical Aerial Photographs

Table 2. Historical Topographic Maps

Table 3. Sediment Removal In Berryessa Creek Project Reach (1977 to 1999)

Table 1. Historical Aerial Photographs

Aerial Photo Date	Source	Scale	Series	Print Number(s)
1939	USDA Adjustment Administration	1:20,000	CIV284	4, 6, 8, 10, 21, 22, 24, 26, 28, 30, 53, 55, 57
1950	USDA Agricultural Stabilization and Conservation Service	1:20,000	C1V 17G; C1V 16G	10, 12, 14, 16, 25, 27, 29, 31, 74, 76, 78; 136, 138
1963	USDA Agricultural Stabilization and Conservation Service	1:20,000	C1V 7DD; C1V 6DD; C1V 2DD	30, 32, 34, 36; 56, 58, 121, 122; 10, 12, 14
1987	USGS National Aerial Photography Program	1:40,000	519; 511	88, 90; 24, 26
2001	Radman Aerial Surveys	1:2880	210044	1-1 to 1-4; 2-1 to 2-7; 3-1 to 3-4; 4-1 to 4-4

Notes: USGS = U.S. Geological Survey
USDA = U.S. Department of Agriculture

Table 2. Historical Topographic Maps

Map Name	Author	Edition	Surveyed	Scale	Notes
Calaveras Reservoir, California	USGS	1980	1953	1:24,000	Photorevised 1978
Milpitas, California	USGS	1980	1961	1:24,000	Photorevised 1979
Calaveras Reservoir, California	USGS	1961	1953	1:24,000	Photorevised 1960
Milpitas, California	USGS	1961	1953	1:24,000	Photorevised 1960
San Jose, California	USGS	1961	1953-61	1:62,500	
Calaveras Reservoir, California	USGS	1953	1953	1:24,000	
Milpitas, California	USGS	1953	1953	1:24,000	
San Jose, California	USGS	1953	1953	1:62,500	
San Jose, California	U.S. Army Map Service	1943	1942	1:62,500	
San Jose, California	USGS	1926	1895	1:62,500	reprint of 1899
Plat of the Pueblo Lands of San Jose	U.S. Surveyor General	1879	1866-79	80ch = 1"	
Township 6 South, Range 1West (T6S, R1W)	U.S. Surveyor General	1873	to 1866	30ch = 1"	
Township 5 South, Range 1 West (T5S, R1W)	U.S. Surveyor General	1872	1851-64	30ch = 1"	
Township 5 South, Range 1 East (T5S, R1E)	U.S. Surveyor General	1866	1851-66	30ch = 1"	
Township 6 South, Range 1 East (T6S, R1E)	U.S. Surveyor General	1872	1851-71	30ch = 1"	
Map of the Rancho Los Tularcitos	U.S. Surveyor General	1859	1859	20ch = 1"	
Plat of the Rancho de los Esteros	U.S. Surveyor General	1858	1858	20ch = 1"	
Map of the Milpitas Rancho	U.S. Surveyor General	1857	1857	30ch = 1"	

Notes: USGS = U.S. Geological Survey
ch = chain (1 chain = 65.3 ft)

Table 3. Sediment Removal In Berryessa Creek Project Reach (1977 to 1999)

Fiscal Year (FY)	Start Date	End Date	Description	Stream Length (ft)	Sediment Removed (yd^3)
1981	8/15/80	10/6/80	Berryessa Creek, Calaveras Blvd D/S to WPRR	6,100	4,210
1982	9/29/81	11/4/81	Berryessa Creek, D/S from Calaveras Blvd to Lower Penitentia Creek	8,600	23,510
1985	7/31/84	8/11/84	Berryessa Creek, Lower Penitencia confluence to SPRR	2,200	19,500
1986	8/13/85	9/5/85	Berryessa Creek, Calaveras Blvd D/S to SPRR	6,400	14,352
1987	9/3/86	11/18/86	Berryessa Creek, Lower Penitencia Creek to Jacklin	2,400	360
1987	9/12/86	9/12/86	Berryessa Creek, U/S Abel Street	10	460
1987	10/24/86	10/27/86	Berryessa Creek, U/S Abel Street Culvert	20	460
1987	9/3/86	11/18/86	Berryessa Creek, Lower Penitencia Creek to Jacklin	2,400	9,000
1989	9/26/88	10/21/88	Berryessa Creek, Calaveras Blvd D/S to SPRR	6,300	13,330
1990	9/14/89	11/9/89	Berryessa Creek, D/S Calaveras Blvd.	8,900	7,100
1991	9/21/90	9/27/90	Berryessa Creek, D/S SPRR	2,400	3,420
1992	8/23/91	9/18/91	Berryessa Creek, D/S SPRR	2,400	4,066
1994	7/12/93	9/17/93	Berryessa Creek, D/S Calaveras Blvd.	3,100	2,800
1998	8/10/97	12/1/97	Berryessa Creek, D/S Los Coches Creek	9,350	30,000
1999	9/28/98	11/2/98	Berryessa Creek, Lower Penitencia Creek to Calaveras Blvd.	8,600	33,040
				TOTAL =	**165,608**

LIST OF FIGURES

Figure 1. Watershed Map

Figure 2. 2001 Channel Invert Profile of Berryessa Creek

Figure 3. Historical Planform Shift Map

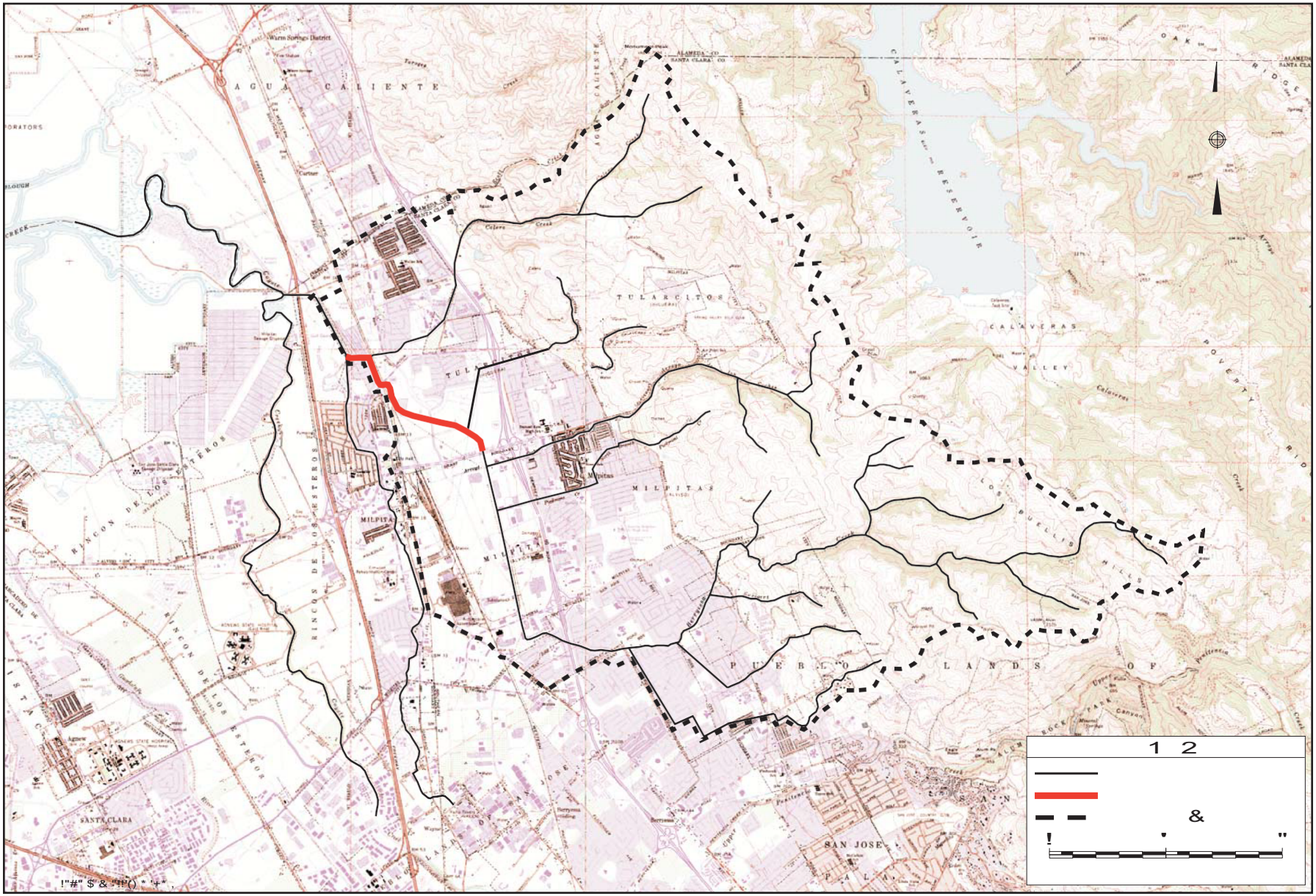
Figure 4. Channel Invert Profiles of Berryessa Creek in Project Reach from 1976, 1997, and 2001

Figure 5. Comparison of 1976 and 2001 Cross Sections on Berryessa Creek at Station 56+27

Figure 6. Comparison of 1976 and 2001 Cross Sections on Berryessa Creek at Station 65+18

Figure 7. Comparison of 1976 and 2001 Cross Sections on Berryessa Creek at Station 90+20

Figure 8. Comparison of 1976 and 2001 Cross Sections on Berryessa Creek at Station 114+72


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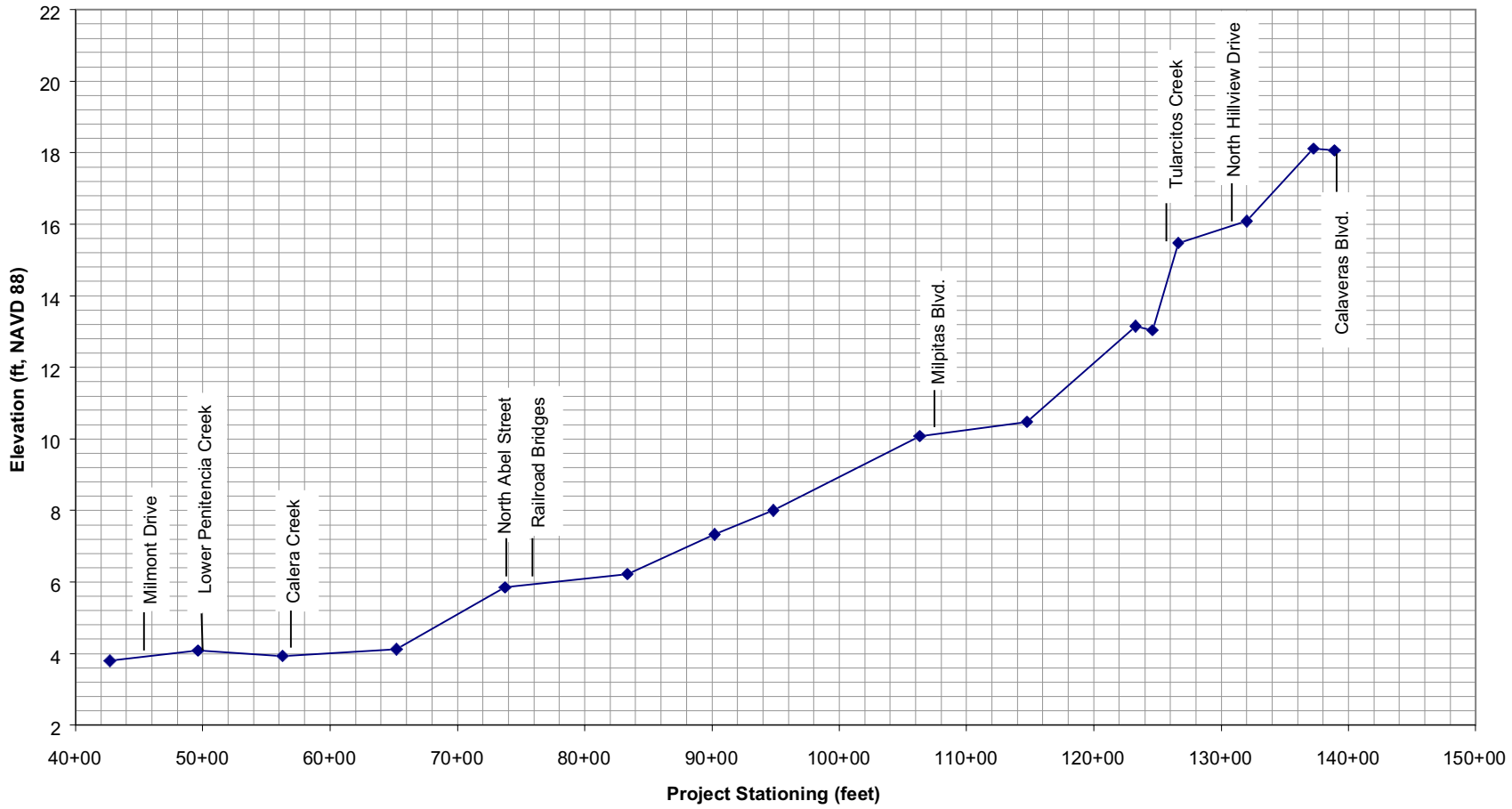
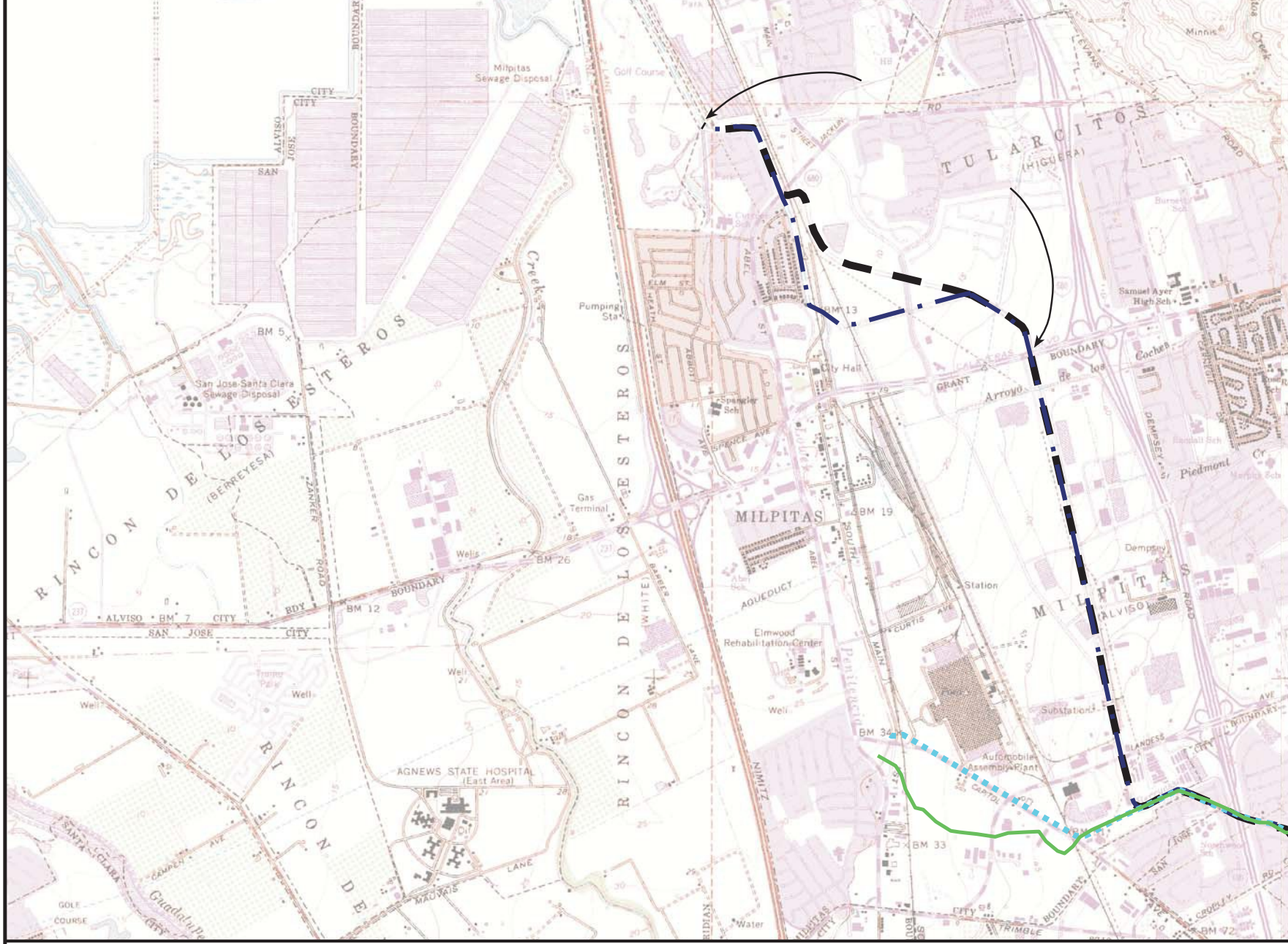


Figure 2
2001 Channel Invert Profile of Berryessa Creek
In Project Reach
August 30, 2001


Milpitas Sewage Disposal
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BOUNDARY
ALVISO
SAN JOSE
Creek
Pumping Sta
BM 5
San Jose-Santa Clara Sewage Disposal
RINCON DE LOS ESTEROS
(BERRYESSA)
ZANKER ROAD
Gas Terminal
Wells
BM 26
BM 12
ALVISO BM 7
BDY
WHITE
RINCON DE LOS ESTEROS
AGNEWS STATE HOSPITAL
(East Area)
GOLF COURSE
Water
BM 13
City Hall
Spangler Sch
GRANT
Arroyo de los Coches
Samuel Ayer High Sch
TULARCITOS
(HIGUERA)
MILPITAS
BM 19
AQUEDUCT
Elmwood Rehabilitation Center
Station
Substations
Automobile Assembly Plant
BM 34
BM 33
NIMITZ
Piedmont
Dempsey
MILPITAS
ALVISO
Minnis Creek

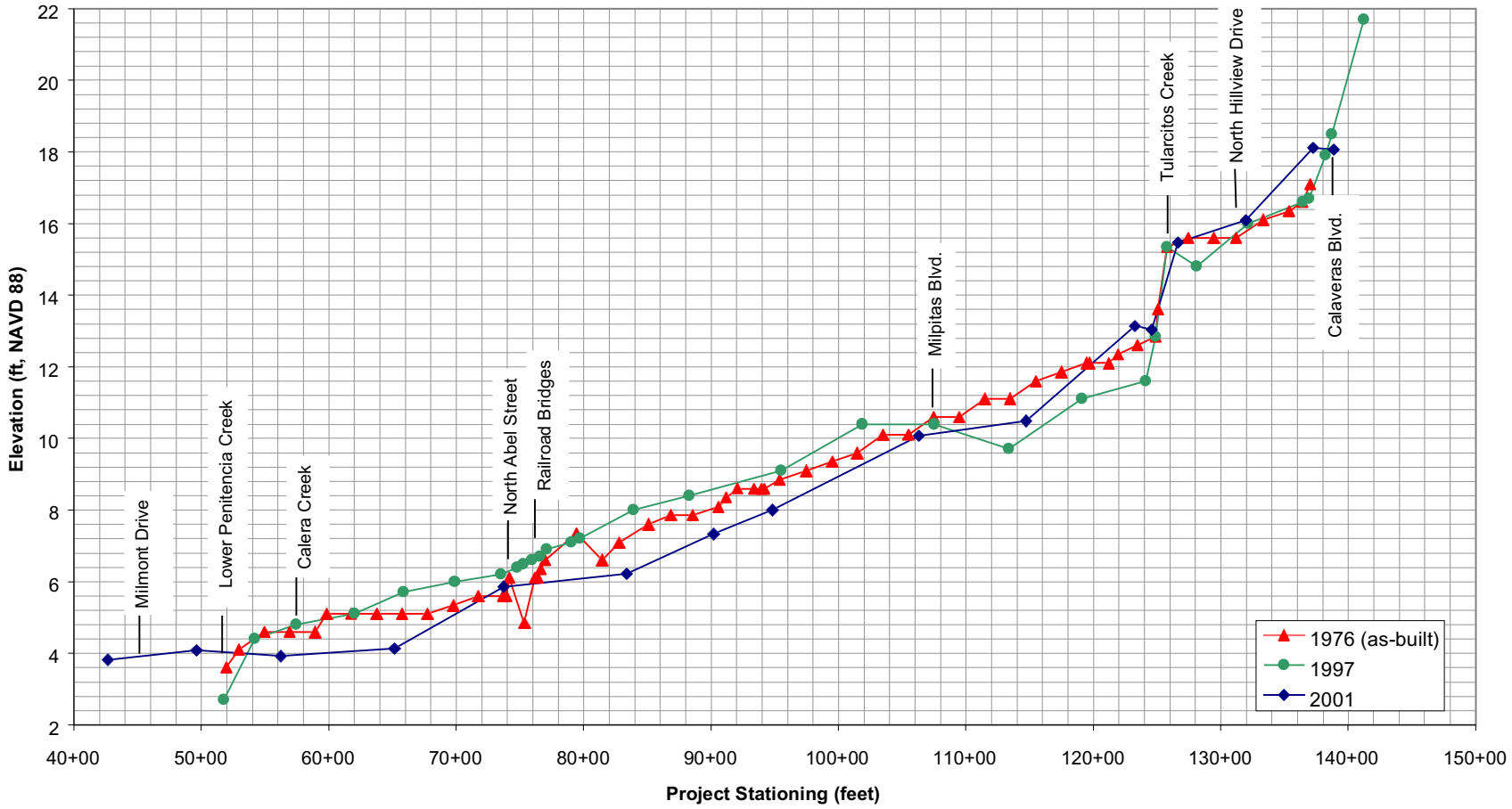


Figure 4
Channel Invert Profiles of Berryessa Creek
In Project Reach from 1976, 1997, and 2001
August 30, 2001

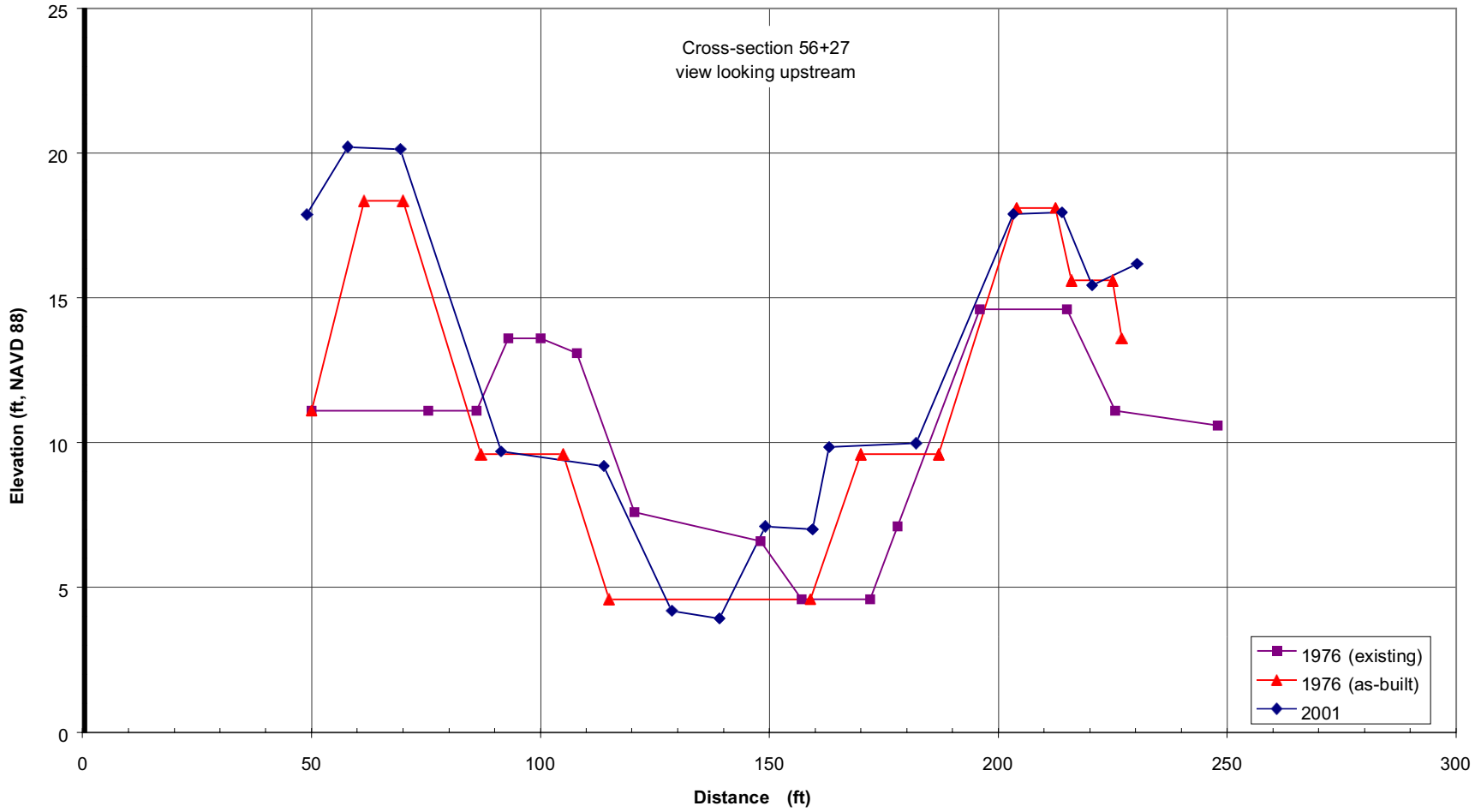


Figure 5
Comparison of 1976 and 2001 Cross-Sections on Berryessa Creek at Station 56+27
August 30, 2001

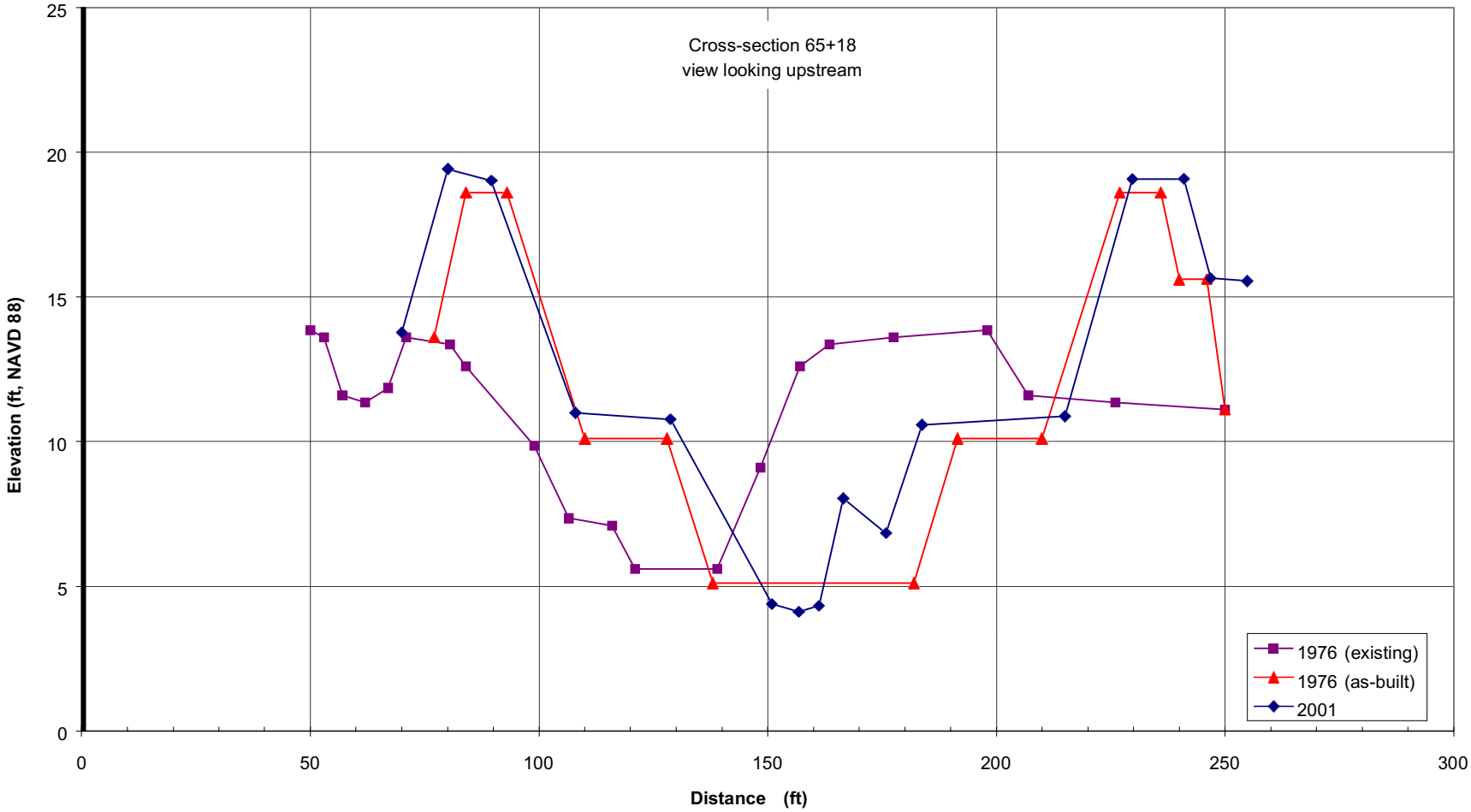


Figure 6
Comparison of 1976 and 2001 Cross-Sections on Berryessa Creek at Station 65+18
August 30, 2001

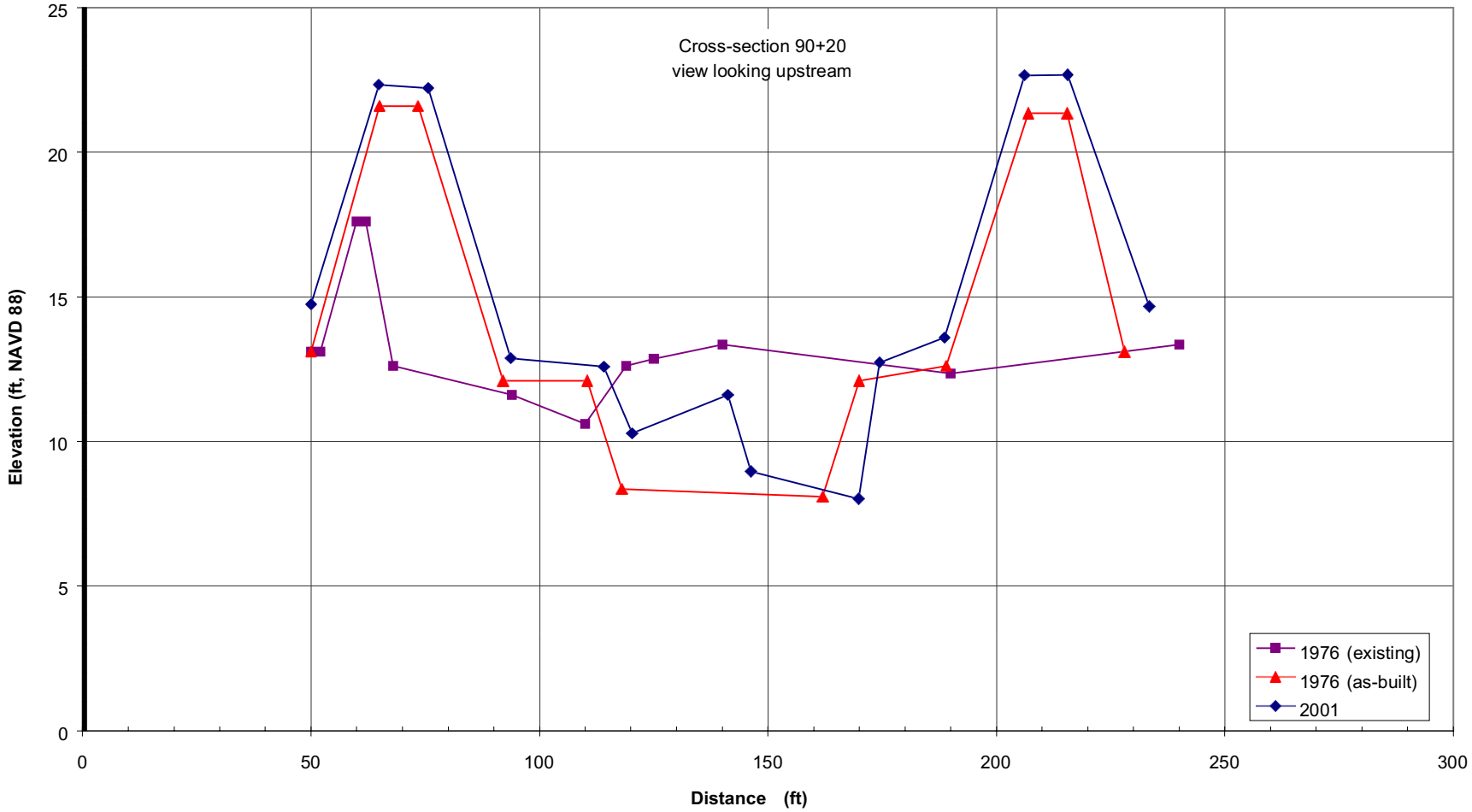


Figure 7
Comparison of 1976 and 2001 Cross-Sections on Berryessa Creek at Station 90+20
August 30, 2001

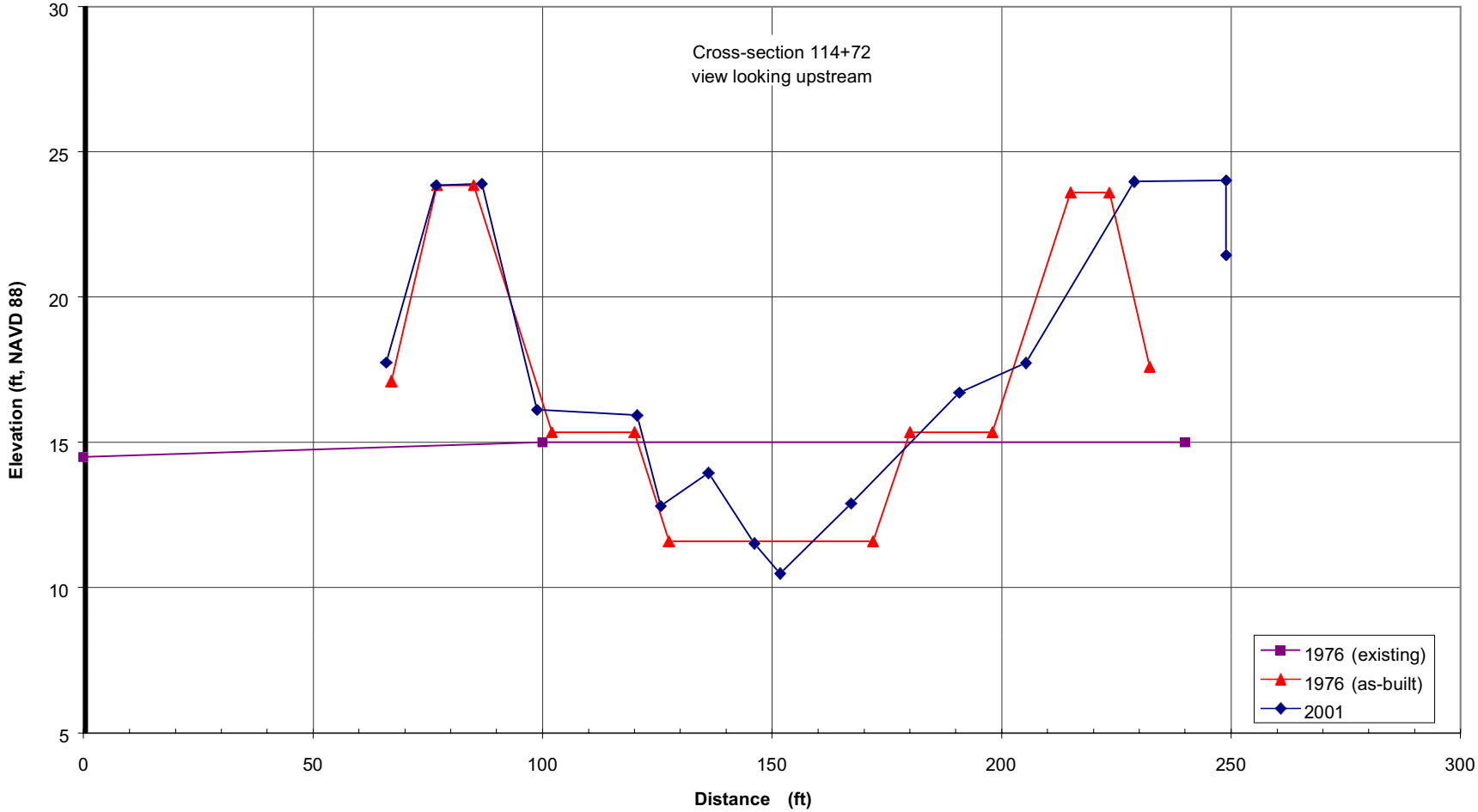


Figure 8
Comparison of 1976 and 2001 Cross-Sections on Berryessa Creek at Station 114+72
August 30, 2001

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APPENDIX B – HYDROLOGY STUDY

Berryessa Creek Watershed Hydrology Report

Report Date: April 2003
Addendum 1: October 2006

Prepared for:

Coyote Watershed Program
Santa Clara Valley Water District

and

US Army Corps of Engineers
Sacramento District

nhc

Berryessa Creek Watershed
Hydrology Report
Addendum 1

Lower Berryessa Creek Project
#401704

October 2006

Prepared for:

Coyote Watershed Program
Santa Clara Valley Water District
2290 North 1st Street, Suite 212
San Jose, CA 95131

and

US Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, CA 95814

Prepared by:
Northwest Hydraulic Consultants, Inc.
3950 Industrial Boulevard, Suite 100C
West Sacramento, CA 95691

nhc

Addendum to the April 2003 Berryessa Creek Watershed Hydrology Report

Purpose

northwest hydraulic consultants, inc. (**nhc**) was retained by Winzler and Kelly (W&K) on behalf of the Santa Clara Valley Water District (District) to revise an existing HEC-HMS hydrologic model of the Berryessa Creek watershed to account for possible future drainage improvements along tributaries to Berryessa Creek.

Background

nhc developed an HEC-HMS hydrologic model of the Berryessa Creek watershed for the District in April 2003. That model assumed break out flow could occur along Piedmont, Los Coches, or Tularcitos Creeks if flows exceeded the existing channel capacity in those tributaries. Subsequent to the 2003 study, the District determined that hydrology for the Berryessa Creek basin should consider a condition without break out flows. For this reason the District directed W&K to retain **nhc** to modify the 2003 HEC-HMS future land use (full build out) conditions model to eliminate break out flow conditions previously modeled and reported in April 2003. This addendum summarizes the changes made to the original April 2003 HEC-HMS model and the results from the modified October 2006 HEC-HMS model of the Berryessa Creek Watershed.

Approach

In order to remove break out flow from the original 2003 HEC-HMS model the following steps were taken:

1. The April 2003 HEC-HMS future land use conditions (i.e. full build out assumption) model was retrieved from the project archives.
2. The HEC-HMS model was translated from HEC-HMS version 2.2.1 to version 3.0.1.
3. Results from the version 3.0.1 model were compared to results from the original version 2.2.1 model to ensure that the results reported in 2003 could be replicated within an acceptable tolerance using the most recent version of HEC-HMS.
4. The HEC-HMS model was updated to remove the breakout flows previously assumed in 2003.
5. The no breakout flow model was run to provide peak flows at the locations listed in Table 15 found in the April 2003 report as well as the additional locations listed in Winzler & Kelly's October 2005 technical memorandum to the District.

These steps are described in greater detail below.

The original model results were developed using HEC-HMS version 2.2.1. Because version 2.2.1 has been superseded and is no longer being actively supported by HEC, **nhc** converted the model into the current HEC-HMS code (version 3.0.1). To ensure that the conversion did not cause any changes in flows, results from the new version 3.0.1 model were compared with the results from the original 2.2.1 version. Comparison of the version 3.0.1 results confirmed that flows at all points matched the results from the April 2003 study to within 0.1 cfs. Once it was known that the HEC-HMS version 3.0.1 model could reproduce the earlier results, the model input records were modified to remove the breakout flow assumptions previously specified on Piedmont, Los Coches, and Tularcitos tributaries as per the request from the District and W&K.

Break out flows in the original HEC-HMS model were simulated using diversion elements on Piedmont, Los Coches, and Tularcitos Creeks. The reaches representing these creeks used the Modified Puls routing method, which requires a storage-discharge table for each routing reach. Therefore, when the flow diversions were removed in the modified HEC-HMS model, new storage-discharge tables were required for these creeks. For the present study the required storage-discharge tables were developed using available hydraulic information and the following HEC-RAS models:

Berryessa Creek Alternative 2 model provided by W&K,

Tularcitos Creek Alternative 2 model provided by W&K,

nhc model of Piedmont Creek developed for the 2003 study, and

nhc model of Los Coches Creek developed for the 2003 study.

W&K's Berryessa Creek Alternative 2 HEC-RAS model was extended upstream by **nhc** to the confluence of Piedmont Creek using seven cross sections from the HEC-2 model of Berryessa Creek provided to **nhc** by the District in 2003, with appropriate elevation adjustments.

New storage-discharge tables were developed using an iterative process to balance flows between the modified Berryessa watershed HEC-HMS model and HEC-RAS models listed above. Flows from the HEC-HMS model were inserted into the HEC-RAS model of Berryessa Creek and used to establish tailwater ratings for the tributaries. These tailwater elevations were then used in the tributary models to calculate new storage-discharge tables for Tularcitos, Los Coches, and Piedmont Creeks. These updated storage-discharge tables were then inserted into the HEC-HMS model and run to produce new flow estimates for the tributaries and mainstem of Berryessa Creek. The new flows were then reinserted into the HEC-RAS models and the process was repeated until the flows calculated by the HEC-HMS model converged. The new storage-discharge tables are shown in Table 13a on the following page.

New flows were computed with the newly updated future land use (full build out) condition HEC-HMS model with the assumption that no breakout flows would occur on Piedmont, Los Coches, or Tularcitos Creeks. Results from these simulations for the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500- year recurrence intervals are summarized below in revised Table 15a.

Table 13 a. Modified Puls Parameters
Updated Storage-Discharge Tables for Piedmont, Los Coches, and Tularcitos Creeks

RP4-B17 Piedmont Creek

Storage (ac-ft)	**Discharge** (cfs)
0	0
1.20	41
7.18	301
10.08	470
11.30	539
15.09	842
17.63	1084
21.70	1330
25.70	1671
29.18	1880

RT4-T3 Tularcitos Creek

Storage (ac-ft)	**Discharge** (cfs)
0	0
2.20	27
8.78	230
13.18	364
15.77	448
23.13	664
29.08	865
40.63	1203
54.47	1332
70.52	1565

RLC-B17a Los Coches Creek

Storage (ac-ft)	**Discharge** (cfs)
0	0
0.19	36
0.87	252
1.33	411
1.65	541
2.51	781
3.33	996
4.87	1275
6.5	1597
7.63	1865

Revised Table 15a. 24-Hour Storm Flood Frequency Quantiles

Location	Drainage Area (sq mi)	HMS Node	Recurrence Interval (yrs)	Future Conditions (cfs)[1]
Lower Penitencia Creek Above Confluence with Coyote Creek	29.1	B33	2	2,480
			5	3,640
			10	4,310
			25	5,900
			50	6,980
			100	8,720
			200	10,790
			500	12,080
Lower Penitencia Creek Below Confluence with Berryessa Creek	28.2	B29	2	2,320
			5	3,490
			10	4,160
			25	5,760
			50	6,840
			100	8,400
			200	10,770
			500	12,080
Berryessa Creek at Downstream End Immediately Above Confluence w/ Lower Penitencia Creek	22.4	B27	2	1,720
			5	2,680
			10	3,160
			25	4,500
			50	5,490
			100	6,960
			200	9,040
			500	10,210
Berryessa Creek at North Abel Street Below Confluence with Wrigley-Ford Ditch	19.4	B25	2	1,590
			5	2,390
			10	2,810
			25	3,970
			50	4,820
			100	6,260
			200	7,720
			500	9,270
Berryessa Creek Berryessa Pump Station	17.8	B23	2	1,370
			5	2,120
			10	2,540
			25	3,590
			50	4,480
			100	5,710
			200	7,540
			500	8,670
Berryessa Creek Below Confluence with Tularcitos Creek	17.3	B21	2	1,280
			5	2,010
			10	2,420
			25	3,500
			50	4,360
			100	5,700
			200	7,140
			500	8,380

Revised Table 15a. 24-Hour Storm Flood Frequency Quantiles (Cont.)

Location	Drainage Area (sq mi)	HMS Node	Recurrence Interval (yrs)	Future Conditions (cfs)[1]
Berryessa Creek at Calaveras Boulevard	15.10	B19	2	1,090
			5	1,720
			10	2,060
			25	3,060
			50	3,830
			100	4,990
			200	6,090
			500	7,150
Berryessa Creek Below Confluence with Piedmont Creek	11.2	B17	2	830
			5	1,350
			10	1,600
			25	2,440
			50	2,990
			100	3,880
			200	4,780
			500	5,630
Berryessa Creek at Yosemite Rd	9.20	B15	2	620
			5	990
			10	1,170
			25	1,770
			50	2,200
			100	2,910
			200	3,580
			500	4,290
Berryessa Creek at Landess Road	8.91	B13	2	610
			5	960
			10	1,120
			25	1,620
			50	2,020
			100	2,780
			200	3,490
			500	4,200
Berryessa Creek Below Confluence with Sierra Creek (Morrill Rd)	7.70	B11	2	470
			5	710
			10	830
			25	1,260
			50	1,630
			100	2,140
			200	2,660
			500	3,140
Berryessa Creek Below Confluence with Crosley Creek	5.75	B9	2	300
			5	500
			10	700
			25	1,000
			50	1,340
			100	1,740
			200	2,220
			500	2,600

Revised Table 15a. 24-Hour Storm Flood Frequency Quantiles (Cont.)

Location	Drainage Area (sq mi)	HMS Node	Recurrence Interval (yrs)	Future Conditions (cfs)[1]
Berryessa Creek Below Confluence with Sweigert Creek	4.91	B7	2	260
			5	450
			10	600
			25	890
			50	1,180
			100	1,530
			200	1,960
			500	2,300
Berryessa Creek at Old Piedmont Road	4.40	B5	2	240
			5	420
			10	560
			25	830
			50	1,090
			100	1,430
			200	1,820
			500	2,130
Piedmont Creek at Mouth		RP4-B17	2	230
			5	370
			10	440
			25	720
			50	960
			100	1,150
			200	1,380
			500	1,580
Arroyo de Los Coches at Mouth		RCL8-B17a	2	250
			5	410
			10	540
			25	780
			50	990
			100	1,270
			200	1,600
			500	1,860
Tularcitos Creek at Mouth		RT4-T3	2	190
			5	290
			10	360
			25	530
			50	650
			100	830
			200	970
			500	1,150
Calera Creek at Mouth		CAL3	2	170
			5	280
			10	360
			25	510
			50	650
			100	840
			200	1,070
			500	1,230

[1]**Revised flows as of October 2006**

Errata

While translating the April 2003 HEC-HMS model from version 2.1.1 to version 3.0.1 a few minor typographical errors in the Tables from the April 2003 report were found. Corrections to these tables are shown below.

Correction to Table 6. 24-Hour Storm Loss Rate Parameters

The initial loss rate for sub-basins B2, B4, B6, B8, B10, CAL2, CR2, LC2, LC4, LC6, P2, SIE2, ST2, SW2, and T2 in the 200-500 year HEC-HMS basin models was 0.27 inches. Table 6 in the report erroneously listed these as 0.24 inches. However, these parameters were entered correctly in the original 2003 model.

Correction to Table 9. Percent Impervious and Pervious Area by Subbasin

Table 9 should have listed the following values for future land-use condition impervious and pervious area percentages for the LP8, LP16, and ST2 sub-basins.

Future Condition		
Subbasin	**% Impervious**	**% Pervious**
LP8	31.0	69.0
LP16	71.0	29.0
ST2	14.0	86.0

Correction to Table 12. Stream Reach Characteristics and Muskingum Routing Parameters

The Muskingum K, Muskingum X, and N steps columns in the 2003 report were entered out of order. These parameters were entered correctly in the original 2003 model. The corrected table is shown below.

Reach Name	Reach Length	Reach Slope	Velocity	Muskingum K	Muskingum X	N Steps
RLC1-LC2	1.204	0.0408	6.0	0.29	0.25	2
RB1-B3	1.473	0.0831	6.0	0.36	0.25	3
RB3-B5	1.872	0.0544	6.0	0.46	0.25	3

Berryessa Creek Watershed Hydrology Report

April 2003

Prepared for:
Coyote Watershed Program
Santa Clara Valley Water District

and

US Army Corps of Engineers
Sacramento District

nhc

Berryessa Creek Watershed Hydrology Report

Berryessa Creek Levees Project
#401704

April 2003

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1 INTRODUCTION

1.1 General Information

This report documents the hydrologic analysis of the Berryessa Creek drainage basin in Santa Clara County, California, as performed by northwest hydraulic consultants, inc. (**nhc**). The objectives of this report are to summarize the analyses undertaken, document data and key assumptions, and present the results of the hydrologic study. The study was conducted to estimate peak flow discharges at key locations along Berryessa Creek for use in the design and evaluation of a flood damage reduction project for the reach of Berryessa Creek between Calaveras Boulevard and Lower Penitencia Creek. This study was undertaken at the request of the Santa Clara Valley Water District (SCVWD) in accordance with their need to provide flood control improvements.

This study consisted of the development and application of an HEC-HMS rainfall-runoff hydrologic simulation model of the Berryessa Creek drainage basin. Instantaneous peak discharges corresponding to 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedance events were calculated at key index points within the study area of Berryessa Creek. These discharges will be used in the hydraulic analysis and design of the flood impact reduction projects. Peak discharges were calculated for both existing and anticipated future (full build-out) land-use conditions based on available land use information provided by the SCVWD.

The hydrologic data developed in this study will also be used by the Sacramento District of the Corps of Engineers (COE) for a flood damage reduction project on Berryessa Creek between Old Piedmont Road and Calaveras Boulevard. To accommodate requirements of the Corps of Engineers' project, an extended duration storm was developed and simulated to estimate runoff volumes for longer duration storm events.

This report provides information on the hydrometeorologic and geographic characteristics of the watershed and their effect on runoff and flooding potential. This report also describes the development of the HEC-HMS model, derivation of input data used in the model, key assumptions, and results from the hydrologic investigation. The data, assumptions, methods, and results presented herein have been thoroughly reviewed and accepted by the SCVWD and the COE.

1.2 Study Area

The Berryessa Creek drainage basin is located northeast of San Jose, California, as shown in Figure 1. The basin is located immediately north of the Upper Penitencia Creek drainage basin. Berryessa Creek flows west out of the foothills of the Diablo Range in Santa Clara County, then continues in a westerly direction through the southern portion of the City of Milpitas. The creek flows north through the City of Milpitas, joining Lower Penitencia Creek approximately 4,400 feet above the confluence of Lower Penitencia Creek and Coyote Creek. Coyote Creek enters the San Francisco Bay approximately 10 miles northwest of San Jose. The Berryessa Creek drainage basin encompasses 22.4 square miles of rural and urban land upstream of its confluence with Lower Penitencia Creek. The Lower Penitencia Creek basin, at its confluence with Coyote Creek, drains approximately 29 square miles. Ground elevations in the basin range from 2,600 feet above mean sea level (msl) in the foothills to 10 feet above msl at the confluence with Coyote Creek.

1.3 Climate

The Berryessa Creek basin lies within a region that has a mild Mediterranean climate. This is characterized by almost all of the rainfall occurring between November and early April, and mild temperatures that are rarely below freezing during the winter and seldom exceed 100 degrees during the

summer. Long term temperature and precipitation data are available from the National Weather Service's San Jose Climatological Station 7821, located approximately 5.5 miles south of the Berryessa Creek basin. The mean annual temperature at this station is 60.1 degrees Fahrenheit (ºF). The average monthly temperature ranges from a low of 49.1ºF in December to a high of 69.5ºF in July. The mean annual precipitation at the San Jose station is 14.42 inches, with the month of June being the driest and January being the wettest. Climatological data for this station are summarized in Table 1 (Owenby and Ezell, 1992).

Precipitation events in the Berryessa Creek basin are predominately a result of either orographic or cyclonic effects. Orographic storms occur when moist air rises, cools and condenses as it moves over the Diablo Hills and mountain range. Cyclonic storms are the result of air masses moving from regions of higher barometric pressure to lower pressure zones. Additionally, cyclonic storms may be the result of frontal activity. Broad bands of low intensity rainfall are associated with warm fronts, while higher intensity rainfall is associated with cold fronts (Schaaf and Wheeler, 2001). Cloudburst storms or convective type storms with intense central rain and limited spatial distribution rarely occur.

1.4 Flood Characteristics

Flooding resulting from intense widespread precipitation over the Santa Clara Valley and Diablo Range typically occurs between November and April. These floods are characterized by high peak flows of moderate durations which are intensified when the ground is saturated. The storms that lead to flooding are typically cyclonic storms originating in the Pacific Ocean.

Runoff from urban areas in the basin is conveyed to main channels by municipal storm drainage systems. Streets serve as temporary collection basins upstream of the storm drainage systems. During extreme rainfall events, when flows exceed the capacity of the storm drainage system, excess water flows overland and down the streets. Localized flooding in the urban portions of the basin results from undersized storm drains and sediment or debris clogging the storm drain inlets. More damaging flooding is induced by inadequate channel capacities in major collection and conveyance systems such as Berryessa Creek.

2 HYDROLOGIC MODEL

2.1 Overview

Observed stream flow data for Berryessa Creek are minimal and out of date, and it is therefore necessary to generate synthetic design flow data using a hydrologic model. The hydrologic model developed for this study includes the entire Berryessa Creek watershed. The hydrologic model also includes the Lower Penitencia Creek watershed, even though this project does not include the design of flood control facilities on Lower Penitencia Creek. Lower Penitencia Creek was included in the model because flow in Lower Penitencia Creek will affect the hydraulics of Berryessa Creek, and thus may affect the design of flood control measures on Berryessa Creek.

The model selected to simulate the rainfall-runoff processes for Berryessa Creek is the U.S. Army Corps of Engineers' Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS). Within HEC-HMS, runoff is simulated for a large basin by evaluating runoff from a number of smaller subbasins. The runoff from these smaller subbasins is routed to the main channel, combined with flow from other subbasins, and routed down the main channel. This approach can provide a reasonably accurate, process based, representation of flow paths, storage, and attenuation across the watershed.

HEC-HMS requires the input of data to define the estimation of rainfall excess, the transformation of this excess into direct runoff within each subbasin, the estimation of baseflow, and the routing of computed

flood hydrographs in the main channel. The following subsections describe the modeling methods used and the process in which the input data were developed.

2.2 Subbasin Delineation

The Berryessa Creek and Lower Penitencia Creek drainage basins were divided into two general categories: urbanized and rural. Descriptions of these categories are provided below.

1. *Urban Areas*: The majority of urban development in the Berryessa Creek basin is located in the lower elevation and western portion of the basin within the Milpitas city limits. Essentially all of the Lower Penitencia Creek basin is urbanized. Single-family housing, apartment complexes, shopping centers, schools, and industrial areas create a high percentage of impervious cover. All conveyance features are improved to some degree. These features vary from slightly improved open channels to complex underground storm drain systems. Urban areas are characterized by ground slopes of about 1 percent (0.01 $^{ft}/_{ft}$). Soils maps of the area (SCS, 1964) indicate that younger clays are interspersed with smaller amounts of old San Francisco Bay mud in the vicinity of the creeks. Much of the soil in the urban area is either clay or clayey loam and is thus associated with very low infiltration rates when wetted, resulting in high runoff potential. Closer to Coyote Creek the soil becomes loamier, and is thus characterized by better infiltration characteristics and moderate to high runoff potential.

2. *Rural Areas*: Under existing conditions, the higher elevation portions of the Berryessa Creek basin, representing the foothills area east of Old Piedmont Road, are either undeveloped or sparsely developed. The tributary channels in the upper basin wind through gently rolling grass-covered hills. The upper basin is characterized by slopes of 5 to 6 percent (0.05 to 0.06 $^{ft}/_{ft}$) with minimal impervious cover. The soils are shallow with high clay content. Stream channels are commonly flanked by brush and deciduous trees. The width of the riparian zone along these channels varies from several hundred yards in the channels of Berryessa Creek and Arroyo de Los Coches, to a few yards on the smaller tributaries.

For hydrologic modeling purposes, the study area was divided into 39 subbasins (see Figure 2). The rural zone was divided into 16 subbasins, representing the foothill basins of Berryessa Creek, Piedmont Creek, Sierra Creek, Crosley Creek, Sweigert Creek, Arroyo de Los Coches, Tularcitos Creek, and Calera Creek. The lower (urban) region was divided into 23 subbasins, each representing to an area of similar flow patterns and urbanization. The drainage divides defining these subbasins were established by referencing U.S. Geological Survey quadrangles, county storm drainage design maps, field inspections, the Milpitas Master Drainage Plan and consultations with City staff familiar with the area (Schaaf and Wheeler, 2001; Delorme, 2000).

2.3 Precipitation Data

Rainfall hyetographs were developed for the 2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-year return periods. At the direction of the Santa Clara Valley Water District, all of the modeled storm events use the same rainfall distribution. The prescribed distribution is the 24-hour rainfall pattern developed by the COE for their 1982 hydrologic study of Berryessa Creek (USACE 1982). This unitless distribution is shown in Table 2. The hyetograph for a particular storm event was determined by multiplying the percentage of rainfall in each time step by the total rainfall depth for the event.

The 24-hour rainfall totals for the 2- through 100-year storms were derived using the NOAA Atlas 2 (NOAA 1973). As a result of orographic effects, precipitation is significantly greater at the higher elevations in the basin than at lower elevations. To accurately simulate the spatial variability of precipitation during a large event, the study area subbasins were grouped into three representative precipitation regions, labeled Urban Penitencia, Urban Berryessa and Foothills (Table 3). Individual

subbasins were grouped into one of these three regions based on the NOAA Atlas 2 isopluvials in or adjacent to the subbasin. The location of the three precipitation regions is shown in Figure 3. To determine precipitation depth, a map of the study area and delineated subbasins was digitally overlaid onto 2- through 100-year isopluvial maps from NOAA Atlas 2, and average precipitation depths were determined for each of the three regions.

Because the NOAA Atlas does not include isopluvial maps for 200- and 500-year events, the precipitation depths for these return periods were extrapolated from a log-normal plot of the 2- through 100-year NOAA Atlas 2 rainfall depths (see Figure 4). Other statistical distributions were examined, but the log-normal distribution shown in Figure 4 provided the best fit to the data.

Depth-area reduction factors were applied to the 24-hour rainfall volumes to account for the size of the drainage basins in the study area. The values of the depth-area reduction factors were determined from Figure 14 in the NOAA Atlas 2 and applied to the storm precipitation totals. The reduction factor for the Urban Berryessa and the Foothills regions is 0.972. This value corresponds to a storm centered over the entire 22.36 mi^2 Berryessa Creek drainage basin, and the value is obtained directly from the 24-hour duration depth-area curve in Figure 14.

The depth-area reduction factor for the Urban Penitencia region is 0.943, which was derived through an indirect procedure. The value for the Urban Penitencia region corresponds to the reduction factor necessary to generate a "concurrent storm" over the 5.88 mi^2 Lower Penitencia Creek drainage basin. The concurrent storm is the rainfall that occurs over the Lower Penitencia Creek drainage basin while a storm of a specific recurrence interval is occurring over the Berryessa Creek drainage basin. This approach was justified because Lower Penitencia Creek was not being analyzed for the purpose of designing flood control features along the Lower Penitencia Creek channel, but rather to establish boundary conditions at the downstream end of Berryessa Creek. Therefore, flow rates on Lower Penitencia Creek during a concurrent storm are theoretically more applicable for the design of flood protection features on Berryessa Creek than peak flow rates associated with an equal recurrence interval storm over the Lower Penitencia Creek basin. The reduction factor for the Lower Penitencia Creek basin was obtained by first determining the depth-area reduction factor for the 28.24 mi^2 combined Berryessa Creek and Lower Penitencia Creek drainage basin (0.966 from NOAA Atlas 2 Figure 14, 24-hour duration curve). The final step was to calculate the value that must be applied to only the 5.88 mi^2 Lower Penitencia Creek basin if 0.972 is applied to the 22.36 mi^2 Berryessa Creek basin, and 0.966 is the appropriate depth area reduction value to apply to the 28.24mi^2 combined basin. This is represented in equation form as:

$$(0.966)(28.24) = (0.972)(22.36) + x(5.88)$$

The rainfall depths for each region and return period, with depth-area reduction factors applied, are presented in Table 4.

At the request of the Corps of Engineers, 1-, 6-, 12- and 24-hour rainfall depths used in this study were compared to data from precipitation gages located near the study area. This comparison is shown in Table 5. There are four precipitation gages within the drainage basin boundaries or near the study area: San Jose, Penitencia Water Treatment Plant, Curtner Ranch and Haskins Ranch. The depths reported for the gage data were developed by Jim Goodridge, former California State Climatologist with the Department of Water Resources. The San Jose gage had a record length of approximately 90 years, while the other three gages had record lengths between 22 and 29 years. Comparison of these data does not show a strong correlation. For all recurrence intervals, the gage data has greater depths for shorter duration storms such as the 1-hour storm, whereas the NOAA data has greater depths for longer duration storms such as the 24-hour storm. Differences between the data derived from the NOAA Atlas 2 and the data from local gages is possibly a result of the difference in the time span over which the data were

collected, or possibly the procedures used by NOAA to develop the Atlas 2 isopluvial mapping. The SCVWD and COE selected to use the NOAA Atlas 2 data for this study rather than the local gage data.

2.4 Precipitation Excess

For this analysis, rainfall losses due to interception, depression storage, and infiltration, are estimated in the HEC-HMS model using the initial and constant loss rate method. With this method, interception and depression storage are represented with an initial loss. Precipitation on pervious surfaces only contributes to runoff after a volume equal to this initial loss has occurred since the beginning of the storm event, and thereafter only the amount of rainfall in excess of the constant loss rate contributes to runoff.

Initial and constant losses were estimated based on values used by the San Francisco District, Corps of Engineers for the hydrologic evaluation of Upper Penitencia Creek (USACE 2001). Initial and constant losses were increased slightly for the rural, upland areas based on the assumption that these areas would consist of more permeable, undisturbed soils. The adopted initial losses and constant loss rates are listed in Table 6.

2.5 Baseflow

Baseflow in the study area is minimal and has a negligible effect on flood peaks. For this analysis the exponential recession model was selected for base flow simulation. This method requires the user to input an initial flow at the beginning of the storm event (typically the average annual flow in the channel), a recession constant that is dependent on the basin size and type of flow expected to contribute to base flow, and a threshold value which defines the time when the recession model defines the total flow. Three different sets of parameters were adopted based on the location of the subbasin. These parameters are listed in Table 7.

2.6 Land Use

An important consideration in the development of the HEC-HMS model is the proper classification of land cover as either pervious or impervious. Runoff rates are highly influenced by the amount of land in a basin that is impervious. Increased imperviousness, as found in urban areas, results in reduced opportunity for infiltration and thus increased runoff. Streets, gutters, rooftops, parking lots, driveways, and similar areas are considered impervious areas when determining the percentage of imperviousness in each subbasin. Hard packed soil, such as gravel roads and parking lots, are also considered as impervious for purposes of the hydrologic modeling.

Geographical Information System (GIS) mapping of existing and future land-use conditions was used to estimate percent pervious and impervious cover for each subbasin. These land-use maps, shown in Figures 5 and 6, provide a spatial representation of land-use in digital format. From these maps, the amount of each type of land-use was calculated for the individual subbasins through use of the GIS.

The existing conditions land use map was developed from several sources, including 1993 aerial photography of the City of Milpitas for the urban areas and 1970 land use delineation by the USEPA for the rural areas. After reviewing the available maps, eight general categories of land use were selected to define the varying land use in the basin. These are: Commercial/Industrial (CI), Forested (F), Grassland (GL), Park (PK), High Density Residential (R-1), Medium Density Residential (R-2), Low Density Residential (R-3), and Rural Residential (R-4). Figure 5 shows the drainage basin delineated by existing conditions land use.

Once the land use within the drainage basin was delineated, an estimate of the percent of impervious coverage that typically occurs within each specific land use category is made. This was done by

estimating pervious and impervious coverage for representative areas within each land-use classification and using this to assign an impervious percentage for the classification. The amount of impervious land cover in a particular subbasin is calculated as the product of the area of each land use category within the subbasin and the percent impervious cover associated with the specific land use category. Note that modeled percent impervious areas may be lower than the actual impervious coverage in a basin. This is because some portion of impervious surfaces may discharge onto pervious areas prior to reaching a stormwater collection system (e.g., residential rooftops may drain onto splash blocks and across lawns before entering the storm drainage system). The estimated percent of effective impervious cover for each land use category is shown in Table 8. The percentage of impervious land cover for each subbasin is shown in Table 9.

A future conditions land use map of the study area (Figure 6) was developed from zoning maps included in the General Plans for the cities of Milpitas and San Jose, and Santa Clara County. The future land use conditions map represents a full build-out condition in the study area, as defined by the General Plans. Future land use conversions, such as from grassland to residential or from residential to industrial are simulated in HEC-HMS model by increasing the percentage of impervious land cover. Future conditions impervious coverage is estimated using a similar procedure as was described for the existing conditions land-use. Table 9 lists the estimated future conditions impervious areas by subbasin.

2.7 Rural Subbasin Runoff Method

The unit hydrograph method was selected as the most applicable method to transform excess precipitation to runoff in the rural portions of the Berryessa Creek basin. Representative unit hydrographs were developed using the summation-curve method (S-curve). The S-curve used to determine subbasin unit hydrographs for this study was originally developed by the Sacramento District, Corps of Engineers in their 1982 hydrologic analysis of Berryessa Creek (USACE 1982). The Corps of Engineers developed an S-curve based on reconstitution of historical events recorded at the streamflow gage on Upper Penitencia Creek. The drainage basin upstream of the Upper Penitencia Creek streamflow gage is located immediately south of the Berryessa Creek drainage basin and has generally similar topographic and land-use characteristics.

Unit hydrographs for each subbasin were developed by calculating and applying a Basin Lag or shaping factor unique to each subbasin. The San Francisco District, Corps of Engineers District-wide relationship for lag was used for this analysis and is:

$$\text{Basin Lag} = 24n((L\ L_{CA})/S^{1/2})^{0.38}$$

Where:

- Lag = time from the start of the runoff to a point where 50-percent of the ultimate unit hydrograph runoff has occurred, in hours;
- n = average roughness coefficient for the basin, dimensionless;
- L = length (longest flow path) of the main watercourse, in miles; and
- L_{CA} = length (flow path) on the main watercourse from a point closest to the center of area of the basin to the basin outlet, in miles.
- S = slope of the basin, in feet/mile

Basin lag parameters used in the HEC-HMS model for each of the rural subbasins are summarized in Table 10.

2.8 Urban Subbasin Runoff Method

The kinematic wave method was used to transform excess precipitation to runoff in the urban areas within the Berryessa Creek and Lower Penitencia Creek drainage basins. The kinematic wave method was selected because there were insufficient data available to develop reliable unit hydrographs for the urban areas. The kinematic wave method is a conceptual model of watershed response. It utilizes input parameters for the drainage subbasins that can be estimated from physical basin characteristics (e.g., slope, distance, channel shape) and provides a reasonable means of transforming excess precipitation to runoff when data are not available for unit hydrograph calibration. A detailed description of this technique is contained in "Introduction and Application of Kinematic Wave Routing Techniques Used in HEC-1", (USACE 1993).

The Kinematic Wave runoff hydrograph is shaped by routing excess precipitation through a theoretical series of open channels. First the runoff is routed through an overland flow plain (a wide shallow channel) that represents sheet flow. The runoff is then routed through sub-collector channels, which typically represent gutters, then through collector channels, which represent major ditches or storm drain pipes, to the downstream end of the subbasin. Each of these routings are calculated using the momentum and continuity equations to simulate unsteady open channel flow. The kinematic wave parameters used in the HEC-HMS model for the urban subbasins are listed in Table 11.

2.9 Rural Hillside Streamflow Routing

The Muskingum routing method was used for routing flow hydrographs through creek channel reaches in the undeveloped hillside areas. Flow velocity was initially estimated using Manning's equation assuming the roughness coefficient (n) was equal to 0.045; however, this produced flow velocities that seemed unrealistically high. A more reasonable estimate of flow velocity for the upper basin channels of 6 feet per second was used for the Muskingum routing calculations. The Muskingum travel time, K, was estimated as the stream length divided by velocity. Lacking calibration data to accurately calculate the Muskingum X value, a value of 0.25 was assumed appropriate for the streams involved because it is the midpoint of the typical range of values. The number of calculation steps was estimated based on the travel time and a time step of fifteen minutes used in the HEC-HMS simulations. Table 12 shows the Muskingum routing parameters used in this analysis.

2.10 Urban Area Main Channel Streamflow Routing

The Modified Puls method was used to route flow hydrographs through the urban reaches of Berryessa Creek. The required storage-outflow relationship for each sub-reach was produced using an HEC-RAS model created from several existing HEC-2 models of Berryessa Creek and Lower Penitencia Creek provided by the SCVWD from work done during previous studies. The composite HEC-RAS model was modified to eliminate levee overtopping by incorporating infinitely high, vertical, frictionless walls at the top of the bank along both sides of the channel. This was done to contain all flow in the main Berryessa Creek channel, as is anticipated following completion of the proposed Berryessa Creek flood control projects.

Sub-reaches were defined between key locations, such as the confluence of tributary streams, pump station outlets, or significant road crossings. A range of flows was analyzed with the HEC-RAS model to develop storage versus discharge relationships for the hydrologic model.

The Modified Puls method was also used to create routing reaches for portions of Lower Penitencia, Tularcitos, Los Coches and Piedmont Creeks. Storage-outflow tables were developed from HEC-RAS models of each creek. The models were based on channel cross sections surveyed by **nhc** in April 2002.

Because the HEC-HMS model was assumed to include future improvements on these channels, flow in the HEC-RAS model was confined to the channel, as was done for the main stem of Berryessa Creek.

The Modified Puls routing parameters for all applicable reaches are shown in Table 13. Figure 7 is a schematic diagram of the HEC-HMS model, and shows the relative locations and connectivity of all the nodes listed in Table 13.

2.11 Pump Station Data

Levees are present along portions of Berryessa and Lower Penitencia Creeks. These levees provide flood protection, but also function as a barrier that can prevent runoff generated on the land behind the levees from flowing directly into the creeks. In these areas, runoff is routed to low elevation locations (or sumps) and pumped into the creek. There are nine pump stations in the study area which are designed to convey interior runoff to the creeks: California Circle, Minnis, Abbott, Penitencia, Berryessa, Jurgens, Wrigley-Ford, Manor and Spence Creek.

Elevation-area-outflow or storage-outflow data were input into the HEC-HMS model for each of the pump stations based on data from the City of Milpitas Master Drainage Plan (Schaaf & Wheeler, 2001) or provided by Schaaf & Wheeler. Pump station data are summarized in Table 14. Relative locations of the pump stations are shown in Figure 7.

2.12 Breakout Flow Routing

The existing Berryessa Creek channel has insufficient capacity to convey all of the flow during large storm events. When floods greater than approximately a 10-year recurrence interval occur under existing conditions, flow overtops the banks and spills onto the floodplain at some locations. This allows significant attenuation of the flood hydrograph, reducing the peak flow downstream of breakout locations. Because the purpose of the current Berryessa Creek projects is to reduce flooding by improving channel capacity, this hydrologic analysis assumed that Berryessa Creek would be able to convey all of the simulated design flows without overtopping. This is a necessary assumption to be able to predict appropriate peak flow rates for project design purposes along the entire length of the creek channel.

For the tributary channels, however, it is unknown at this time to what extent flood improvements will be implemented in the near future. At the direction of the SCVWD, this study assumed that no improvements will be made on any of the tributaries to Berryessa Creek, or on Lower Penitencia Creek. At some locations on the tributary creeks, high flows spill over the channel banks or "break out" and travel overland, either re-entering the tributary creek further downstream or flowing overland into a different subbasin. These breakout flows are simulated in the HEC-HMS model through the use of flow diversion tables inserted in the affected flow reaches. Figure 7 provides a schematic diagram of all the flow connections in the model, including breakout flows.

Several breakout flow locations were identified along tributary streams in the study area. A culvert on Piedmont Creek immediately upstream of I-680 was calculated to have a maximum capacity of 900 cfs; flows greater than 900 cfs will break out of the channel and travel north along South Park Victoria Drive, eventually entering Los Coches Creek. The culvert under I-680 on Los Coches Creek was calculated to have a maximum capacity of 800 cfs, and excess flows will break out and flow north along South Park Victoria Drive. Based on available topography and field investigations, the assumed overland flow path of the breakout flows from Los Coches Creek is west along Calaveras Boulevard. A portion of the breakout flow will enter Berryessa Creek at the Calaveras Boulevard bridge, and the remainder of the flow will continue west along the roadway, ultimately reaching the Wrigley Creek subbasin.

The reach of Tularcitos Creek downstream of I-680 was calculated to have a maximum capacity of 700 cfs. Flows greater than 700 cfs will overtop the channel and travel north. This flow will end up in subbasin B20, which is drained by the Berryessa pump station.

Other culvert crossings along the tributary creeks were evaluated, but overtopping flows in these areas were thought likely to re-enter the same creek channel immediately downstream of the crossing, thus no breakout flows are modeled in these reaches.

2.13 Subbasin Storage

At the request of the SCVWD, an investigation was performed to determine if the routing storage implicitly calculated using the kinematic wave procedure in the urban portions of the study area is reasonable. The initial concern was that the simplified approach utilized by the kinematic wave method in HEC-HMS would underestimate storage, thus decreasing flow attenuation and increasing peak flow rates. The investigation included: (1) field observations and measurements to locate areas where additional flow storage could occur, (2) manual routing calculations to determine the volume of storage in selected storm drain pipe systems and associated roadway gutters when storms of greater magnitude than the design storm event occur, and (3) calculation of storage at the upstream end of culvert crossings. The results from these calculations were compared to the volumes of storage calculated by HEC-HMS when using the kinematic wave method.

The investigation found that the kinematic wave method in HEC-HMS was adequately calculating storage for all the subbasins in the Berryessa Creek drainage basin. However, at two locations in the Lower Penitencia Creek drainage basin the investigation indicated that the kinematic wave method was potentially underestimating the amount of storage that would occur during extremely large flooding events. At these two locations in Lower Penitencia Creek, storage was added by inserting a reservoir storage table at the downstream end of the subbasins.

The first area that appeared to require additional storage was the farthest upstream subbasin of Lower Penitencia Creek (subbasin LP2). There is no open channel in this subbasin, and Lower Penitencia Creek is essentially defined by three large storm drain pipes. When the capacity of the storm drain system is exceeded, excess runoff flows north towards the open channels that are the beginning of Lower Penitencia Creek. A portion of the excess flow is likely to travel overland towards the west and pond against the Interstate 880 embankment. Because the hydraulic connections within of this subbasin during large storm events are very complex and no measured data or anecdotal observations of large flood events were available for **nhc** to use as a basis for modifying the HEC-HMS model, and because the study of this creek is only necessary to establish boundary conditions for the proposed project on Berryessa Creek, the SCVWD decided to implement a simplifying assumption rather than perform a detailed interior drainage analysis. The assumption developed by the SCVWD and implemented in the HEC-HMS model was that the maximum rate of flow from the LP2 subbasin would be limited to the capacity of the storm drain system operating with one foot of head on the farthest downstream run of pipe in the storm drain system. Calculations based on storm drain pipe data provided by City of San Jose drainage maps indicated that this assumption limits the flow from LP2 to 800 cfs. In the HEC-HMS model, when runoff from the LP2 subbasin exceeds 800 cfs, the excess flow is temporarily placed in storage until the runoff from the subbasin drops below 800 cfs, at which time the volume in storage is routed out of the subbasin at a maximum rate of 800 cfs. In the HEC-HMS model there is no limit to the volume of storage that is available to maintain a maximum outflow rate of 800 cfs for any flooding event, and **nhc** did not investigate if the amount of storage used by the HEC-HMS model is physically reasonable for the LP2 subbasin.

The other area that appeared to require additional storage was subbasin LP4, specifically the area along Lower Penitencia Creek between Great Mall Parkway and Calaveras Boulevard. When flow in the creek

exceeds 1200 cfs, the hydraulic capacity of a series of culverts in this area is exceeded. The excess flow overtops the channel and would be expected to pond in the topographically flat area east of Lower Penitencia Creek and west of Wrigley-Ford Creek. To simulate this storage, a reservoir storage table was added to the HEC-HMS model at the downstream end of subbasin LP4. When flow in the main channel of Lower Penitencia Creek through LP4 exceeds 1,200 cfs, a portion of the excess flow is temporarily placed in storage. The volume of available storage was determined from topography maps of the Lower Penitencia Creek floodplain. The relationship of the amount of runoff in storage to the flow in the main channel of the creek was based on the hydraulic characteristics of the limiting culverts and the available storage.

3 RESULTS – PEAK FLOW ANALYSIS

3.1 Peak Flow Frequency Curves

Eight storm events, corresponding to the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedance events (2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-year recurrence intervals) in the Berryessa Creek drainage basin, were simulated using the HEC-HMS model. Peak discharges were calculated for both existing and future (full build-out) land-use conditions. Existing conditions 10-, 50-, 100- and 500-year flows at four key locations are summarized in the table below. A complete listing of results from the HEC-HMS model are presented in Table 15. Hydrographs and cumulative flow volumes for the 1- percent chance exceedance event (100-year event) at Old Piedmont Road and Calaveras Boulevard are presented in Figures 8 and 9.

Berryessa Creek - Existing Conditions				
	Peak Flow (cfs)			
Location	10-year	50-year	100-year	500-year
at Old Piedmont Road	530	1,060	1,400	2,110
at Calaveras Boulevard	1,990	3,650	4,690	6,430
at North Abel Street	2,730	4,620	5,580	8,140
at Downstream End of Berryessa Creek	3,050	5,270	6,430	9,180

3.2 Comparison of Peak Flows with Other Data and Studies

To investigate the reasonableness of peak flows calculated with the HEC-HMS model, the results from the model at selected locations were compared to results from regression equations, streamflow gage station flood-frequency analyses, and with previous hydrology studies of the Berryessa Creek basin.

3.2.1 Regression Analysis

The 100-year peak flow rate was calculated for subbasins B2 and CAL2, and for Berryessa Creek at Old Piedmont Road (HEC-HMS index point B5) using the regression equations from the SCVWD Hydrology Procedures manual (Wang, et. al., 1998). These three subbasins were selected to represent a sampling of the rural areas within the Berryessa Creek drainage basin. The regression equations provided in the Hydrology Procedures manual were developed for application to streams with minimal development, and the selection of these three subbasins is consistent with this requirement.

Results from this comparison are presented in Table 16. In addition to the 100-year peak flow rate, confidence intervals corresponding to a 90% confidence level were calculated for each of the basins. This comparison shows that the HEC-HMS model generates a 100-year peak discharge that is within the 90% confidence interval of the regression equations for the two smaller subbasins, and slightly greater than the

upper 90% confidence limit for the Berryessa Creek at Old Piedmont Road subbasin. This indicates that there is some agreement between the HEC-HMS model results and the regression equations, although not an exact match.

3.2.2 Streamflow Gage Data Flood Frequency Analysis

Further evaluation of the HEC-HMS model was accomplished by comparing peak flows calculated by the model to peak flows generated from frequency analysis of available streamflow gage data. Two sets of streamflow gage data were used for this analysis. The first is from a streamflow gage that was operated for a short period of time by the SCVWD on Berryessa Creek at Calaveras Boulevard. The other is from a streamflow gage operated by the USGS on Upper Penitencia Creek (USGS station 11172100) located at the downstream end of the rural portion of that drainage basin. A statistical analysis was performed on both data sets using HEC-FFA (USACE 1992), which is a flood frequency analysis program developed by the Corps of Engineers. The statistical analysis fit a log-Pearson Type III distribution to the data sets.

The Berryessa Creek at Calaveras Boulevard gage represents the most directly useful data set; however, the data set is relatively short (gage operation from 1968 through 1983) and much of the drainage basin has been urbanized since the gage was discontinued. In addition, the Berryessa Creek channel is unable to convey all of the flow during an extremely large flood event. If an extreme event occurred during the period of gage operation, a portion of the flow would have spilled out of the channel onto the floodplain, which would have attenuated the peak, thus reducing the peak flow recorded by the gage. However, the HEC-HMS model for this project assumes flood improvements are in place and all flow is contained within the main channel, so there is no peak attenuation from floodplain storage. With this in mind, the gage information shows a surprisingly good correlation to calculated flows from HEC-HMS.

The Upper Penitencia Creek gage is useful because the drainage basin is adjacent to Berryessa Creek and should have similar rainfall and soil characteristics. The Upper Penitencia Creek basin is slightly larger than the rural portion of the Berryessa Creek drainage basin, and includes a reservoir. Both of these are likely to lead to lowering the peak flow rate in Upper Penitencia Creek. It is useful to compare peak flows from this gage data on a unit basis (cfs/mi^2) to the HEC-HMS simulated flow rates for rural subbasins in Berryessa Creek. As expected, the unit discharge from the Upper Penitencia Creek gage station is lower than the calculated flows in the rural subbasins of Berryessa Creek. However, when the size of the gaged basin and the presence of reservoir storage in the gaged basin are considered, the flows generated from the HEC-HMS model show reasonable agreement to the gaged flows.

A summary of the flood frequency analysis for the two gages is provided in Table 17. These values can be compared to the HEC-HMS model results in Table 15.

3.2.3 Other Berryessa Creek Studies

The Sacramento District of the Corps of Engineers and the SCVWD have previously conducted hydrology studies of Berryessa Creek (USACE 1982, Saah 1978). At three locations along Berryessa Creek, the existing conditions 10- and 100-year recurrence interval peak flows from the present study were compared to the flows predicted in the previous studies. There is a strong correlation between the results of the HEC-HMS model developed for this study and the results of the previous studies. The comparison of flows is shown in Table 18.

4 EXTENDED DURATION STORM

4.1 Background

The analysis discussed in the preceding sections comprised a peak flow hydrology study that was conducted in support of the SCVWD's Berryessa Creek Levees Project. That analysis used a synthetic 24-hour rainfall hyetograph that was developed by nesting maximum rainfall amounts from a series of storm durations (1-, 2-, 3-, 6-, 12-, and 24-hour rainfalls) to create a single hyetograph. This procedure is effective in evaluating the drainage basin runoff response to various storm durations using a single hyetograph. This procedure produces the peak flow for a selected recurrence interval regardless of the critical storm duration at any particular point in the basin; for instance, whether the peak flow is generated by the 1-hour intensity or the 12-hour intensity. This technique is ideal for design considerations for the Berryessa Creek Levees Project because the project is focused on improving flood flow conveyance in the Berryessa Creek channel, which requires an assessment of the peak flow rates for specific recurrence interval storms, but is not concerned with the associated total runoff volumes.

The COE is also evaluating flood improvement opportunities on Berryessa Creek. The COE study is focused on the reach of the creek between Old Piedmont Road and Calaveras Boulevard, immediately upstream of the SCVWD project reach. Peak flow rates must be considered for design of channel improvements; additionally, the COE project is analyzing the effects of floodplain storage for the existing channel and floodplain configurations. The COE may also evaluate opportunities for detention storage of flood flows as a method to reduce flood impacts. While the hydrologic analysis performed for the SCVWD project produces reasonable estimates of peak discharges, the procedure does not produce reliable estimates of runoff volumes for long duration storms. In particular, the short duration storm used in the SCVWD analysis may not be adequate to evaluation of volume dependant issues. Determining reasonable volumes for longer duration storms is necessary for the evaluation of floodplain storage and detention basin design. Because of these additional data needs for the COE project, the COE requested that the present hydrologic analysis include the evaluation of an extended duration storm for the Berryessa Creek basin.

The COE selected a 72-hour storm as the most appropriate extended duration event. Eight storms were developed and simulated corresponding to the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent chance exceedence events (2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-year events) using HEC-HMS. The model developed for the 24-hour peak flow analysis provided the basis for the 72-hour storm model. The hyetograph (discussed in Section 4.2) and the constant soil loss rates (discussed in section 4.3) are the only data in the 24-hour model that were modified for application to the 72-hour storm analysis.

4.2 Hyetograph Development

A 72-hour rainfall distribution was developed by the COE and provided to **nhc** for use in the HEC-HMS model. The distribution is a composite of several large rainfall events recorded at precipitation gages near the Berryessa Creek drainage basin. The distribution is not based on any single storm, but rather has the characteristics of extended duration storms that were identified in the gaged data. The COE distribution consists of an hourly time series, with percent of total storm volume provided for each time step. This unitless distribution is presented in Table 19.

For the 24-hour storm analysis, rainfall volumes were obtained from the NOAA Atlas 2. However, the NOAA Atlas 2 does not include 72-hour rainfall depths so an alternative method was required for the extended duration hydrologic analysis. The COE analyzed regional precipitation gage records to determine an appropriate volume for a 72-hour storm. An evaluation of gage data was previously prepared by Jim Goodridge, a former State Climatologist for the Department of Water Resources. The COE determined that for the study location, the 100-year 72-hour storm depth is approximately equal to

1.69 times the 24-hour storm depth. To verify the appropriateness of this relationship to other recurrence intervals, **nhc** compared the 24- and 72-hour depths for the 2-, 5-, 10-, 25-, 50-, 200- and 500-year storms at precipitation gages relatively near the Berryessa Creek study area. The data comparison indicated that the 72-hour depth is generally 1.69 times greater than the 24-hour depth for all recurrence intervals. Therefore, **nhc** multiplied the 24-hour storm depths from NOAA Atlas 2 by 1.69 to generate 72-hour storm totals. The same basin area reduction factors discussed in Section 2.3 were applied to the 72-hour depths. The 72-hour rainfall depths used in the HEC-HMS model are shown in Table 20. It should be noted that the 72-hour rainfall depths used in this analysis are significantly greater than values generated by the statistical analysis of measured data for any of the four nearby precipitation gages, and significantly greater than the largest 72-hour rainfall amount measured during the period of record at any of the gages. However, the 72-hour rainfall depth used in the analysis has a corresponding relationship to the NOAA data used in the 24-hour analysis.

A set of 72-hour rainfall hyetographs were then developed by applying the 72-hour storm volumes for each recurrence interval to the unitless rainfall distribution provided by the COE.

4.3 Constant Loss Rates

After reviewing preliminary results from the 72-hour storm model, the COE concluded that the soil constant loss rates used in the model were too high for an extended duration storm and the model was not generating as large of a total volume of runoff as the COE expected. The COE determined that while the soil loss rates in the 24-hour storm model were appropriate for the shorter duration storms that control instantaneous peak flows, the soil was more likely to be saturated and have a lower constant loss rate during a long duration storm. Using data from streamflow gages on nearby creeks, the COE developed a ratio between peak flow and mean daily flow for the 50-year and 100-year floods. The COE determined a ratio of less than or equal to 0.20 should occur when comparing the 100-year peak flow (regardless of the storm duration that caused the peak flow) to the mean daily flow resulting from the 100-year 72-hour precipitation.

To achieve the desired ratio, **nhc** applied the 100-year 72-hour precipitation to the HEC-HMS model and modified the constant loss rates for the subbasins upstream of Old Piedmont Road on Berryessa Creek until the average daily runoff from the 100-year 72-hour storm divided by the peak flow for the 100-year return frequency at Old Piedmont Road (see Table 15) was 0.20 or less. When the target ratio for flows was achieved at Old Piedmont Road, the amount of change applied to the constant loss rates in the subbasins upstream of Old Piedmont Road was applied to all other subbasins in the HEC-HMS model. The values for the soil loss rates for the 72-hour storm model are listed in Table 21.

4.4 Results

Existing and future conditions flows were simulated for the 2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-year 72-hour events using the HEC-HMS model. To be useful for hydraulic analysis and design, the results of the extended duration storm analysis need to include the entire runoff hydrograph. Inclusion of printed tables of that information, for all recurrence interval storms and all key index points is not practical in this report. However, hydrographs at two key locations, Old Piedmont Road and Calaveras Boulevard, are presented in Figures 10 and 11. Cumulative flow volumes are also shown in these figures. A copy of the HEC-HMS model or the associated DSS database file is necessary to obtain hydrographs at other locations and for other recurrence interval storms.

Existing conditions peak flow rates from the 72-hour storm for key recurrence intervals and locations are summarized in the following table.

Berryessa Creek – Existing Conditions, 72-hour Duration Storm				
	Peak Flow (cfs)			
Location	10-year	50-year	100-year	500-year
Old Piedmont Road	240	1,020	1,310	1,870
Calaveras Boulevard	1,720	3,590	4,250	5,900
North Abel Street	2,390	4,640	5,440	7,190
at Downstream End of Berryessa Creek	2,720	5,260	6,250	8,270

Existing conditions total runoff volumes for the same recurrence intervals and locations are summarized in the following table.

Berryessa Creek – Existing Conditions, 72-hour Duration Storm				
	Runoff Volume (ac-ft)			
Location	10-year	50-year	100-year	500-year
at Old Piedmont Road	170	1,180	1,650	2,760
at Calaveras Boulevard	1,720	4,670	6,020	9,220
at North Abel Street	2,610	6,300	8,070	12,300
at Downstream End of Berryessa Creek	2,720	7,130	9,180	14,100

5 SUMMARY

The hydrologic analysis of the Berryessa Creek drainage basin discussed in this report was performed to provide the flow data necessary for the design of the SCVWD's Berryessa Creek Levees Project. Results of this analysis can be used as input to hydraulic and sediment transport models to estimate hydraulic characteristics of Berryessa Creek to support the design of levee improvements and other flood control features.

This hydrologic analysis was performed by northwest hydraulic consultants, as a subconsultant to Winzler & Kelley, for the Santa Clara Valley Water District, Coyote Creek Watershed Program. The analysis follows guidelines and procedures established by the SCVWD, with additional input and review provided by the Sacramento District Corps of Engineers. To the maximum extent practical, this analysis uses established hydrologic and engineering guidelines and methodologies. Due to the complexity of the system under study and lack of measured data for hydrologic model calibration, this analysis required several simplifying assumptions to be made. As noted in the text of this report, the SCVWD and the COE provided significant direction with regard to the data and assumptions used in this analysis.

References:

Delorme, 2000. 3-D TopoQuads: Northern California. Yarmouth, ME.

NOAA, 1973. *NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume XI California*, National Oceanic and Atmospheric Administration, Silver Spring, MD, 1973

Owenby, J.R. and Ezell, D.S., 1992. Climatography of the United States No. 81: Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1961-1990.

Saah, A.D, 1978. *Documentation for the East Flood Control Zone*, Santa Clara Valley Water District, July 1978

Schaaf and Wheeler, 2001. *Storm Drain Master Plan*, City of Milpitas, California.

SCS, 1964. Soils Maps, Santa Clara County, California, United States Department of Agriculture, Soil Conservation Service March 1964

USACE, 1982. *Hydrology Office Report, Berryessa Creek, Santa Clara County, CA*, U.S. Army Corps of Engineers, Sacramento, CA

USACE, 1990. *HEC-1 Flood Hydrograph Package, Users Manual*. U.S. Army Corps of Engineers Hydrologic Engineering Center, Davis, CA, September 1990.

USACE, 1992. *HEC-FFA Flood Frequency Analysis, Users Manual.* U.S. Army Corps of Engineers Hydrologic Engineering Center, Davis, CA, May 1992.

USACE, 1993. *Introduction an Application of Kinematic Wave Routing Techniques Using HEC-1*. U.S. Army Corps of Engineers Hydrologic Engineering Center, Davis, CA, July 1993

USACE, 2000. *Hydrologic Engineering Office Report, Upper Penitencia Creek, Santa Clara County, CA*, U.S. Army Corps of Engineers, San Francisco, CA

USACE, 2001a. *HEC-RAS River Analysis System, Version 3.0 Users Manual*. U.S. Army Corps of Engineers Hydrologic Engineering Center, Davis, CA, January 2001.

USACE, 2001b. *Hydrologic Modeling System, HEC-HMS, Version 2.1 Users Manual.* U.S. Army Corps of Engineers Hydrologic Engineering Center, Davis, CA, January 2001.

Wang, J.C., Chang, W., Marks, T.L., and Tabios, G.Q., 1998. *Santa Clara Valley Water District Hydrology Procedures*, December 1998.

Water Resources Council, 1981. *Bulletin 17B: Guidelines for Determining Flood Flow Frequency*. United States Water Resources Council, Washington D.C., Revised September 1981.

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Table 1. Climate Data at San Jose Gage Station (NOAA Gage 7821, 1961 to 1990)

	Temperature (°F)				Precipitation (in.)	
	Ave Min	Ave Max	Mean	Median	Mean	Median
Annual	49.1	71.0	60.1	60.1	14.42	14.26
January	40.6	58.2	49.4	49.1	2.78	2.27
February	43.9	62.5	53.2	53.3	2.16	1.37
March	45.4	65.3	55.4	55.2	2.58	2.04
April	47.1	70.0	58.6	58.0	1.17	0.64
May	50.9	74.6	62.7	63.2	0.26	0.07
June	54.6	79.6	67.1	67.2	0.05	0.00
July	56.6	82.4	69.5	69.3	0.06	0.00
August	56.8	82.0	69.4	69.6	0.12	0.00
September	55.8	80.6	68.2	67.8	0.24	0.03
October	51.6	74.5	63.1	63.3	0.90	0.70
November	45.5	64.4	55.0	55.4	2.11	1.57
December	40.7	57.5	49.1	49.1	1.99	2.00

Table 2. 24-Hour Rainfall Distribution

Time (hrs)	% of Storm Total	Time (hrs)	% of Storm Total	Time (hrs)	% of Storm Total	Time (hrs)	% of Storm Total
0.25	0.5	6.25	0.7	12.25	1.2	18.25	1.1
0.50	0.5	6.50	0.7	12.50	1.2	18.50	1.1
0.75	0.6	6.75	0.7	12.75	1.2	18.75	1.1
1.00	0.6	7.00	0.8	13.00	1.4	19.00	1.1
1.25	0.5	7.25	0.7	13.25	1.5	19.25	1.1
1.50	0.5	7.50	0.7	13.50	1.5	19.50	1.1
1.75	0.6	7.75	0.8	13.75	1.6	19.75	1.0
2.00	0.6	8.00	0.9	14.00	1.6	20.00	1.0
2.25	0.5	8.25	1.0	14.25	8.6	20.25	0.7
2.50	0.6	8.50	1.1	14.50	3.1	20.50	0.7
2.75	0.6	8.75	1.1	14.75	2.6	20.75	0.7
3.00	0.6	9.00	1.1	15.00	1.9	21.00	0.7
3.25	0.6	9.25	1.1	15.25	1.7	21.25	0.7
3.50	0.6	9.50	1.1	15.50	1.6	21.50	0.7
3.75	0.6	9.75	1.1	15.75	1.4	21.75	0.7
4.00	0.6	10.00	1.1	16.00	1.4	22.00	0.6
4.25	0.6	10.25	1.1	16.25	1.2	22.25	0.7
4.50	0.6	10.50	1.1	16.50	1.2	22.50	0.6
4.75	0.6	10.75	1.1	16.75	1.2	22.75	0.6
5.00	0.7	11.00	1.2	17.00	1.2	23.00	0.6
5.25	0.7	11.25	1.1	17.25	1.2	23.25	0.6
5.50	0.7	11.50	1.1	17.50	1.2	23.50	0.6
5.75	0.7	11.75	1.2	17.75	1.1	23.75	0.6
6.00	0.7	12.00	1.2	18.00	1.1	24.00	0.5

Source: 1982 USACE, *Hydrology Office Report, Berryessa Creek*

Table 3. Subbasins in Precipitation Regions

Urban Penitencia	Urban Berryessa	Foothills
CAL8	B12	B2
LP2	B14	B4
LP4	B16	B6
LP6	B18	B8
LP8	B20	B10
LP10	CAL4	CAL2
LP12	CAL6	CR2
LP14	CR4	LC2
LP16	F2	LC4
	LC8	LC6
	P4	P2
	SIE4	SIE2
	SW4	ST2
	T4	SW2
	W2	T2

Table 4. 24-Hour Precipitation Totals

Region	24-Hour Precipitation Depth (inches)							
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Upper Penitencia	2.07	2.83	3.21	4.15	4.53	5.23	5.72	6.46
Upper Berryessa	2.33	3.21	3.60	4.76	5.25	6.03	6.62	7.48
Foothills	2.62	3.60	4.28	5.44	5.83	6.89	7.52	8.51

Table 5. Comparison of NOAA Data and Precipitation Gage Data (depths in inches)

2-year	NOAA Data			Precipitation Data			
	Urb Pen	Urb Berry	Foothills	San Jose	Pen WTP	Curtner R	Haskins R
1-Hour	0.34	0.38	0.43	0.42	0.45	0.49	0.49
6-Hour	0.89	1.01	1.13	0.92	0.97	1.02	1.20
12-Hour	1.44	1.62	1.82	1.19	1.24	1.27	1.58
24-Hour	2.07	2.33	2.62	1.52	1.42	1.53	1.98
5-year	NOAA Data			Precipitation Data			
	Urb Pen	Urb Berry	Foothills	San Jose	Pen WTP	Curtner R	Haskins R
1-Hour	0.46	0.52	0.58	0.59	0.63	0.69	0.70
6-Hour	1.22	1.38	1.55	1.30	1.37	1.44	1.69
12-Hour	1.96	2.22	2.49	1.68	1.75	1.79	2.23
24-Hour	2.83	3.21	3.60	2.14	2.00	2.16	2.79

Table 5. Comparison of NOAA Data and Precipitation Gage Data (Cont.)

10-year	NOAA Data			Precipitation Data			
	Urb Pen	Urb Berry	Foothills	San Jose	Pen WTP	Curtner R	Haskins R
1-Hour	0.52	0.58	0.69	0.71	0.75	0.82	0.83
6-Hour	1.38	1.55	1.84	1.55	1.64	1.72	2.01
12-Hour	2.22	2.49	2.96	2.01	2.09	2.14	2.66
24-Hour	3.21	3.60	4.28	2.56	2.39	2.57	3.33

25-year	NOAA Data			Precipitation Data			
	Urb Pen	Urb Berry	Foothills	San Jose	Pen WTP	Curtner R	Haskins R
1-Hour	0.67	0.77	0.88	0.85	0.90	0.98	1.00
6-Hour	1.79	2.05	2.35	1.86	1.97	2.07	2.42
12-Hour	2.88	3.30	3.77	2.41	2.51	2.57	3.20
24-Hour	4.15	4.76	5.44	3.07	2.87	3.09	4.00

50-year	NOAA Data			Precipitation Data			
	Urb Pen	Urb Berry	Foothills	San Jose	Pen WTP	Curtner R	Haskins R
1-Hour	0.73	0.85	0.94	0.96	1.01	1.10	1.12
6-Hour	1.95	2.26	2.51	2.09	2.21	2.32	2.72
12-Hour	3.14	3.64	4.04	2.71	2.82	2.88	3.58
24-Hour	4.53	5.25	5.83	3.45	3.22	3.47	4.48

100-year	NOAA Data			Precipitation Data			
	Urb Pen	Urb Berry	Foothills	San Jose	Pen WTP	Curtner R	Haskins R
1-Hour	0.85	0.98	1.12	1.06	1.12	1.22	1.24
6-Hour	2.26	2.60	2.97	2.31	2.44	2.57	3.00
12-Hour	3.63	4.18	4.78	3.00	3.12	3.19	3.96
24-Hour	5.23	6.03	6.89	3.81	3.56	3.84	4.96

200-year	NOAA Data			Precipitation Data			
	Urb Pen	Urb Berry	Foothills	San Jose	Pen WTP	Curtner R	Haskins R
1-Hour	0.93	1.07	1.22	1.16	1.23	1.34	1.36
6-Hour	2.47	2.85	3.24	2.53	2.67	2.81	3.29
12-Hour	3.97	4.59	5.21	3.28	3.41	3.49	4.34
24-Hour	5.72	6.62	7.52	4.17	3.89	4.20	5.42

500-year	NOAA Data			Precipitation Data			
	Urb Pen	Urb Berry	Foothills	San Jose	Pen WTP	Curtner R	Haskins R
1-Hour	1.05	1.21	1.38	1.31	1.36	1.48	1.50
6-Hour	2.78	3.23	3.67	2.86	2.96	3.11	3.64
12-Hour	4.48	5.19	5.89	3.71	3.78	3.87	4.80
24-Hour	6.46	7.48	8.51	4.73	4.31	4.65	6.01

Table 6. 24-Hour Storm Loss Rate Parameters

Subbasin	2-25 Year Basin Model		50-100 Year Basin Model		200-500 Year Basin Model	
	Initial Loss	Constant Loss	Initial Loss	Constant Loss	Initial Loss	Constant Loss
B12	0.23	0.17	0.18	0.14	0.09	0.07
B14	0.23	0.17	0.18	0.14	0.09	0.07
B16	0.23	0.17	0.18	0.14	0.09	0.07
B18	0.23	0.17	0.18	0.14	0.09	0.07
B20	0.23	0.17	0.18	0.14	0.09	0.07
CAL4	0.23	0.17	0.18	0.14	0.09	0.07
CAL6	0.23	0.17	0.18	0.14	0.09	0.07
CAL8	0.23	0.17	0.18	0.14	0.09	0.07
CR4	0.23	0.17	0.18	0.14	0.09	0.07
F2	0.23	0.17	0.18	0.14	0.09	0.07
LC8	0.23	0.17	0.18	0.14	0.09	0.07
LP2	0.23	0.17	0.18	0.14	0.09	0.07
LP4	0.23	0.17	0.18	0.14	0.09	0.07
LP6	0.23	0.17	0.18	0.14	0.09	0.07
LP8	0.23	0.17	0.18	0.14	0.09	0.07
LP10	0.23	0.17	0.18	0.14	0.09	0.07
LP12	0.23	0.17	0.18	0.14	0.09	0.07
LP14	0.23	0.17	0.18	0.14	0.09	0.07
LP16	0.23	0.17	0.18	0.14	0.09	0.07
W4	0.23	0.17	0.18	0.14	0.09	0.07
P4	0.32	0.25	0.27	0.21	0.18	0.14
SIE4	0.32	0.25	0.27	0.21	0.18	0.14
SW4	0.32	0.25	0.27	0.21	0.18	0.14
T4	0.32	0.25	0.27	0.21	0.18	0.14
B2	0.54	0.35	0.45	0.28	0.24	0.21
B4	0.54	0.35	0.45	0.28	0.24	0.21
B6	0.54	0.35	0.45	0.28	0.24	0.21
B8	0.54	0.35	0.45	0.28	0.24	0.21
B10	0.54	0.35	0.45	0.28	0.24	0.21
CAL2	0.54	0.35	0.45	0.28	0.24	0.21
CR2	0.54	0.35	0.45	0.28	0.24	0.21
LC2	0.54	0.35	0.45	0.28	0.24	0.21
LC4	0.54	0.35	0.45	0.28	0.24	0.21
LC6	0.54	0.35	0.45	0.28	0.24	0.21
P2	0.54	0.35	0.45	0.28	0.24	0.21
SIE2	0.54	0.35	0.45	0.28	0.24	0.21
ST2	0.54	0.35	0.45	0.28	0.24	0.21
SW2	0.54	0.35	0.45	0.28	0.24	0.21
T2	0.54	0.35	0.45	0.28	0.24	0.21

Table 7. Baseflow Parameters

Areas	Initial Flow (cfs/mi^2)	Recession Ratio	Threshold Flow (Peak Ratio)
Rural Hillsides	4	0.25	0.15
Urban to Rural Transition	1	0.10	0.10
Pervious Urban Floodplain	1	0.10	0.10

Table 8. Percent Impervious by Land-use Category

Category	% Impervious	% Pervious
Commercial Industrial (CI)	85	15
High Density Residential (R-1)	48	52
Medium Density Residential (R-2)	30	76
Low Density Residential (R-3)	12	88
Rural Residential (R-4)	4	96
Park (Pk)	5	95
Grassland (GL)	0	100
Forested (F)	0	100

Table 9. Percent Impervious and Pervious by Subbasin

Subbasin	Existing Condition		Future Condition		Area (mi^2)
	% Impervious	% Pervious	% Impervious	% Pervious	
B2	0.5	99.5	4.0	96.0	1.03
B4	0.0	100.0	4.0	96.0	0.37
B6	0.0	100.0	4.0	96.0	0.81
B8	0.2	99.8	4.0	96.0	1.20
B10	0.5	99.5	4.0	96.0	0.99
B12	42.0	58.0	43.0	57.0	1.21
B14	76.0	24.0	85.0	15.0	0.29
B16	68.0	32.0	81.0	19.0	0.10
B18	57.0	43.0	70.0	30.0	0.21
B20	40.0	60.0	42.0	58.0	0.54
CAL2	2.0	98.0	6.0	94.0	2.49
CAL4	36.0	64.0	52.0	48.0	0.39
CAL6	76.0	24.0	78.0	22.0	0.06
CAL8	37.0	63.0	45.0	55.0	0.65
CR2	1.0	99.0	5.0	95.0	0.51
CR4	37.0	63.0	37.0	63.0	0.33
F2	70.0	30.0	82.0	18.0	0.56
LC2	3.0	97.0	6.0	94.0	1.57
LC4	2.0	98.0	6.0	94.0	1.40

Table 9. Percent Impervious and Pervious by Subbasin (Cont.)

Subbasin	Existing Condition		Future Condition		Area (mi^2)
	% Impervious	% Pervious	% Impervious	% Pervious	
LC6	4.0	96.0	7.0	93.0	0.41
LC8	49.0	51.0	53.0	47.0	0.40
LP2	29.0	71.0	58.0	42.0	2.98
LP4	56.0	44.0	56.0	44.0	1.31
LP6	39.0	61.0	41.0	59.0	0.19
LP8	36.0	64.0	36.0	64.0	0.11
LP10	38.0	62.0	44.0	56.0	0.26
LP12	69.0	31.0	85.0	15.0	0.14
LP14	60.0	40.0	71.0	29.0	0.15
LP16	79.0	21.0	79.0	21.0	0.09
P2	0.0	100.0	4.0	96.0	0.50
P4	34.0	66.0	39.0	61.0	1.53
SIE2	6.0	94.0	10.0	90.0	0.42
SIE4	36.0	64.0	36.0	64.0	1.53
ST2	15.0	85.0	15.0	85.0	0.38
SW2	3.0	97.0	6.0	94.0	0.25
SW4	20.0	80.0	22.0	78.0	0.25
T2	6.0	94.0	8.0	92.0	0.41
T4	29.0	71.0	35.0	65.0	1.37
W2	70.0	30.0	79.0	21.0	0.85

Table 10. Basin Lag Parameters

Subbasin	Slope (feet/mile)	Longest Flow Length (L) (miles)	Centroidal Length (L_{CA}) (miles)	Basin Ave Roughness (n)	Basin Lag $24n((LL_{CA})/S^{1/2})^{0.38}$ (hours)
B2	301	2.44	0.77	0.10	1.03
B4	465	1.35	0.64	0.10	0.71
B6	612	2.18	0.97	0.10	0.94
B8	465	2.37	0.81	0.10	0.96
B10	396	2.51	1.24	0.10	1.19
CAL2	734	3.40	1.79	0.10	1.36
CR2	676	1.88	1.01	0.10	0.89
LC2	554	2.80	0.68	0.10	0.92
LC4	375	2.25	1.11	0.10	1.10
LC6	449	1.51	0.72	0.10	0.78
P2	697	1.46	0.60	0.10	0.66
SIE2	628	2.41	1.37	0.10	1.11
ST2	486	1.25	0.80	0.10	0.74
SW2	660	1.71	1.03	0.10	0.87
T2	401	1.33	0.67	0.10	0.73

Table 11. Kinematic Wave Parameters

B12	% Total of Subbasin	L (ft)	S (ft/ft)	Roughness	Channel Shape	Z	Collector System Area (mi^2)	Bottom Width or Diam (ft)
Overland (I)	42%	60	0.018	0.100				
Overland (P)	58%	200	0.010	0.250				
Sub-collector		400	0.018	0.013	Trapezoid	8	0.009	0
Main		1,500	0.005	0.018	Circular			2
B14	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	76%	140	0.0086	0.100				
Overland (P)	24%	200	0.0125	0.250				
Sub-collector		400	0.0086	0.013	Trapezoid	8	0.008	0
Main		1,500	0.0110	0.018	Circular			2
B16	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	68%	140	0.0060	0.100				
Overland (P)	32%	180	0.0125	0.250				
Main		110	0.0125	0.018	Circular			2
B18	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	57%	70	0.0025	0.100				
Overland (P)	43%	100	0.0031	0.250				
Sub-collector		400	0.0025	0.013	Trapezoid	8	0.007	0
Collector		660	0.0030	0.018	Circular		0.070	2
Main		400	0.0024	0.018	Circular			5
B20	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	40%	60	0.0040	0.100				
Overland (P)	60%	100	0.0056	0.250				
Sub-collector		400	0.0040	0.013	Trapezoid	8	0.007	0
Collector		800	0.0040	0.018	Circular		0.080	2.5
Main		2,500	0.0040	0.018	Circular			5

Table 11. Kinematic Wave Parameters (Cont.)

CAL4	% Total of Subbasin	L (ft)	S (ft/ft)	Roughness	Channel Shape	Z	Collector System Area (mi^2)	Bottom Width or Diam (ft)
Overland (I)	36%	70	0.007	0.100				
Overland (P)	64%	150	0.014	0.250				
Sub-collector		400	0.007	0.013	Trapezoid	8	0.009	0
Collector		2,180	0.003	0.018	Circular		0.130	2
Main		6,240	0.011	0.070	Trapezoid	1		17
CAL6	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	76%	120	0.005	0.100				
Overland (P)	24%	120	0.010	0.250				
Sub-collector		400	0.005	0.013	Trapezoid	8	0.007	0
Collector		200	0.005	0.018	Circular		0.060	1
Main		900	0.005	0.018	Circular			1.125
CAL8	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	37%	60	0.015	0.100				
Overland (P)	63%	150	0.020	0.250				
Sub-collector		400	0.015	0.013	Trapezoid	8	0.010	0
Collector		800	0.015	0.018	Circular		0.093	3
Main		500	0.008	0.018	Circular			6
CR4	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	37%	60	0.0220	0.100				
Overland (P)	63%	200	0.0250	0.250				
Sub-collector		400	0.0220	0.013	Trapezoid	8	0.007	0
Collector		1,500	0.0167	0.018	Circular		0.066	2
Main		4,920	0.0223	0.027	Trapezoid	1		15
F2	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	70%	120	0.0040	0.100				
Overland (P)	30%	200	0.0036	0.250				
Sub-collector		400	0.0035	0.018	Circular		0.009	2
Collector		820	0.0035	0.018	Circular		0.112	2.5
Main		6,240	0.0020	0.080	Trapezoid	1		12

Table 11. Kinematic Wave Parameters (Cont.)

LC8	% Total of Subbasin	L (ft)	S (ft/ft)	Roughness	Channel Shape	Z	Collector System Area (mi^2)	Bottom Width or Diam (ft)
Overland (I)	49%	60	0.0125	0.100				
Overland (P)	51%	200	0.0160	0.250				
Sub-collector		400	0.0125	0.013	Trapezoid	8	0.007	0
Collector		1,500	0.0050	0.018	Circular		0.068	2
Main		5,470	0.0237	0.020	Trapezoid	1		4
LP2	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	29%	70	0.0058	0.100				
Overland (P)	71%	200	0.0060	0.250				
Sub-collector		400	0.0058	0.013	Trapezoid	8	0.008	0
Collector		1,320	0.0050	0.018	Circular		0.099	2
Main		10,560	0.0020	0.050	Trapezoid	1		20
LP4	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	56%	80	0.0025	0.100				
Overland (P)	44%	200	0.0025	0.250				
Sub-collector		400	0.0025	0.013	Trapezoid	8	0.007	0
Collector		2,000	0.0050	0.018	Circular		0.082	4
Main		7,320	0.0020	0.050	Trapezoid	1		20
LP6	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	39%	60	0.001	0.100				
Overland (P)	61%	100	0.001	0.250				
Sub-collector		400	0.001	0.013	Trapezoid	8	0.008	0
Collector		900	0.001	0.018	Circular		0.095	2.5
Main		200	0.001	0.018	Circular			4
LP8	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	34%	60	0.001	0.100				
Overland (P)	66%	90	0.001	0.250				
Sub-collector		400	0.001	0.013	Trapezoid	8	0.005	0
Collector		800	0.001	0.018	Circular		0.037	2
Main		400	0.001	0.018	Circular			2.5

Table 11. Kinematic Wave Parameters (Cont.)

LP10	% Total of Subbasin	L (ft)	S (ft/ft)	Roughness	Channel Shape	Z	Collector System Area (mi^2)	Bottom Width or Diam (ft)
Overland (I)	38%	65	0.001	0.100				
Overland (P)	62%	100	0.001	0.250				
Sub-collector		400	0.001	0.013	Trapezoid	8	0.007	0
Collector		800	0.001	0.018	Circular		0.065	2
Main		800	0.001	0.018	Circular			4.5
LP12	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	69%	120	0.001	0.100				
Overland (P)	31%	150	0.001	0.250				
Sub-collector		400	0.001	0.013	Trapezoid	8	0.005	0
Main		2,160	0.001	0.018	Circular			3
LP14	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	40%	70	0.001	0.100				
Overland (P)	60%	50	0.001	0.250				
Sub-collector		400	0.001	0.013	Circular		0.004	1.5
Collector		800	0.001	0.018	Circular		0.025	2.5
Main		700	0.001	0.018	Circular			4
LP16	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	21%	50	0.001	0.100				
Overland (P)	79%	50	0.001	0.250				
Sub-collector		400	0.001	0.013	Trapezoid	8	0.004	0
Main		700	0.001	0.018	Circular			2.5
P4	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	34%	60	0.007	0.100				
Overland (P)	66%	200	0.020	0.250				
Sub-collector		400	0.007	0.013	Trapezoid	8	0.008	0
Collector		1,500	0.008	0.018	Circular		0.109	2
Main		7,540	0.018	0.020	Trapezoid	Wall		8

Table 11. Kinematic Wave Parameters (Cont.)

SIE4	% Total of Subbasin	L (ft)	S (ft/ft)	Roughness	Channel Shape	Z	Collector System Area (mi^2)	Bottom Width or Diam (ft)
Overland (I)	36%	60	0.0180	0.100				
Overland (P)	64%	200	0.0500	0.250				
Sub-collector		400	0.0180	0.013	Trapezoid	8	0.009	0
Collector		1,500	0.0077	0.018	Circular		0.102	2
Main		9,300	0.0110	0.030	Trapezoid	2		5
SW4	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	20%	70	0.0870	0.100				
Overland (P)	80%	200	0.1000	0.250				
Sub-collector		400	0.0870	0.013	Trapezoid	8	0.008	0
Collector		1,100	0.0670	0.018	Circular		0.083	2
Main		1,440	0.0556	0.050	Trapezoid	0.5		6
T4	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	29%	60	0.0120	0.100				
Overland (P)	71%	200	0.0200	0.250				
Sub-collector		400	0.0120	0.013	Trapezoid	8	0.010	0
Collector		1,500	0.0088	0.018	Circular		0.137	2
Main		5,250	0.0200	0.065	Trapezoid	1		10
W2	**% Total of Subbasin**	**L (ft)**	**S (ft/ft)**	**Roughness**	**Channel Shape**	**Z**	**Collector System Area (mi^2)**	**Bottom Width or Diam (ft)**
Overland (I)	70%	100	0.0045	0.100				
Overland (P)	30%	200	0.0041	0.250				
Sub-collector		400	0.0045	0.013	Trapezoid	8	0.008	0
Collector		1,500	0.0040	0.018	Circular		0.085	2.5
Main		9,630	0.0036	0.080	Trapezoid	1		12

Table 12. Stream Reach Characteristics and Muskingum Routing Parameters

Reach Name	Reach Length (miles)	Reach Slope (ft/ft)	Velocity (ft/s)	Muskingum K (hours)	Musk. X	N steps
RC1-LC2	1.204	0.0408	6.0	0.36	0.25	3
RB1-B3	1.473	0.0831	6.0	0.46	0.25	3
RB3-B5	1.872	0.0544	6.0	0.29	0.25	2

Table 13. Modified Puls Parameters

Node From B33 To B31 Volume (acre-ft)	Discharge (cfs)
9.41	830
9.50	1,660
9.69	2,650
10.75	5,340
15.92	10,200
17.82	12,200
19.40	14,200

Node From B31 To B29 Volume (acre-ft)	Discharge (cfs)
45.90	830
51.20	1,660
59.12	2,650
82.28	5,340
136.99	10,200
159.82	12,200
199.42	14,200

Node From B29 To B27 Volume (acre-ft)	Discharge (cfs)
6.76	830
9.68	1,660
12.69	2,650
19.58	5,340
30.23	10,200
37.80	12,200
47.79	14,200

Node From B27 To B25 Volume (acre-ft)	Discharge (cfs)
12.23	830
18.41	1,660
24.51	2,650
38.12	5,340
57.90	10,200
69.49	12,200
85.04	14,200

Node From B25 To B23 Volume (acre-ft)	Discharge (cfs)
12.54	830
19.50	1,660
30.81	2,650
61.33	5,340
88.25	10,200
97.72	12,200
107.28	14,200

Node From B23 To B21 Volume (acre-ft)	Discharge (cfs)
23.25	830
38.16	1,660
59.90	2,650
99.00	4,000
130.82	5,340
198.76	10,200
221.76	12,200
244.60	14,200

Table 13. Modified Puls Parameters (Cont.)

Node From B21 To B19	Volume (acre-ft)	Discharge (cfs)
	6.12	830
	9.73	1,660
	13.61	2,650
	29.96	5,340
	54.63	10,200
	62.66	12,200
	70.59	14,200

Node From B19 To B17(a)	Volume (acre-ft)	Discharge (cfs)
	0.52	214
	0.89	428
	1.50	857
	2.04	1,285
	2.54	1,714
	3.00	2,142
	4.91	3,296
	6.23	4,072
	7.14	4,759
	9.44	6,735
	10.80	8,000

Node From B17(a) To B17	Volume (acre-ft)	Discharge (cfs)
	1.43	162
	2.33	324
	3.81	648
	5.18	973
	6.46	1,297
	7.62	1,621
	10.25	2,388
	11.99	2,943
	13.61	3,446
	18.22	5,094
	21.00	6,000

Node From B17 To B15	Volume (acre-ft)	Discharge (cfs)
	0.96	143
	1.61	285
	2.74	571
	3.71	856
	4.56	1,141
	5.33	1,426
	7.09	2,089
	8.40	2,551
	9.57	2,968
	13.33	4,230
	15.50	5,000

Node From B15 To B13	Volume (acre-ft)	Discharge (cfs)
	2.88	130
	4.73	259
	7.79	518
	10.43	777
	12.76	1,037
	14.97	1,296
	19.80	1,895
	22.93	2,304
	25.57	2,674
	34.01	3,741
	40.00	4,500

Node From B13 To B11	Volume (acre-ft)	Discharge (cfs)
	4.94	130
	7.91	259
	12.94	518
	17.39	777
	21.55	1,037
	25.56	1,296
	34.30	1,895
	39.60	2,304
	44.62	2,674
	58.31	3,741
	70.00	4,500

Table 13. Modified Puls Parameters (Cont.)

From / To	Node	Volume (acre-ft)	Discharge (cfs)
	B11	1.19	90
		1.88	181
		3.38	361
		4.98	542
		6.24	722
		7.40	903
		12.05	1,392
		14.32	1,742
		16.04	2,054
		22.17	2,854
B9		25.00	3,250

From / To	Node	Volume (acre-ft)	Discharge (cfs)
	B9	0.77	66
		1.27	131
		2.47	263
		3.64	394
		5.56	526
		6.31	657
		8.84	1,055
		10.56	1,350
		11.95	1,604
		15.99	2,218
B7		20.00	3,000

From / To	Node	Volume (acre-ft)	Discharge (cfs)
	B7	0.50	66
		0.90	131
		1.47	263
		1.89	394
		2.27	526
		2.59	657
		3.46	1,055
		4.02	1,350
		4.56	1,604
		5.94	2,218
B5		7.20	3,000

Table 14. Pump Station Data

Abbott		
Elevation (ft)	**Area (ac)**	**Outflow (cfs)**
0.0	0.00	0.0
3.0	0.01	0.0
8.0	3.11	0.0
8.5	3.43	11.9
9.5	4.05	23.8
10.0	4.36	23.8
12.0	6.42	23.8

Berryessa		
Elevation (ft)	**Area (ac)**	**Outflow (cfs)**
0.0	0.00	0
2.0	2.47	0
4.5	3.09	0
6.0	3.46	50
6.5	3.58	100
7.0	3.70	150
10.0	4.44	150
12.0	4.93	150
20.0	30.0	150

Table 14. Pump Station Data (Cont.)

Cal Circle		
Elevation (ft)	**Area (ac)**	**Outflow (cfs)**
0.0	0.00	0
2.7	0.01	0
4.0	1.06	0
4.5	1.11	0
5.8	1.25	38
6.0	1.27	38
7.5	1.42	76
8.0	1.47	76
9.3	1.61	114
10.0	1.68	114
12.0	2.62	114
14.0	3.20	114

Penitencia		
Elevation (ft)	**Area (ac)**	**Outflow (cfs)**
0.0	0.00	0
5.3	0.01	0
6.3	0.01	20
7.0	0.01	20
8.0	2.18	20
8.3	2.22	40
9.8	2.44	60
12.0	2.75	60
14.0	6.00	60

Jurgens	
Storage (ac-ft)	**Outflow (cfs)**
0.00	0
1.03	150
50.00	150

Manor	
Storage (ac-ft)	**Outflow (cfs)**
0.00	0
0.41	60
30.0	60

Minnis	
Storage (ac-ft)	**Outflow (cfs)**
0.00	0
0.21	30
50.00	30

Spence Creek	
Storage (ac-ft)	**Outflow (cfs)**
0.00	0
0.62	90
50.00	90

Wrigley-Ford	
Storage (ac-ft)	**Outflow (cfs)**
0.00	0
2.98	432
100.00	432
150.00	432
200.00	432

Table 15. 24-Hour Storm Flood Frequency Quantiles

Location	Drainage Area (sq mi)	HMS Node	Recurrence Interval (yrs)	Existing Conditions (cfs)	Future Conditions (cfs)
Lower Penitencia Creek Above Confluence with Coyote Creek	29.1	B33	2	2,150	2,520
			5	3,370	3,660
			10	4,030	4,340
			25	5,780	5,940
			50	6,750	6,930
			100	8,100	8,170
			200	9,790	9,860
			500	11,030	11,060
Lower Penitencia Creek Below Confluence with Berryessa Creek	28.2	B29	2	2,040	2,330
			5	3,210	3,540
			10	3,890	4,210
			25	5,660	5,780
			50	6,600	6,740
			100	7,890	7,960
			200	9,630	9,690
			500	11,030	11,060
Berryessa Creek at Downstream End Immediately Above Confluence w/ Lower Penitencia Creek	22.4	B27	2	1,620	1,730
			5	2,580	2,710
			10	3,050	3,180
			25	4,410	4,510
			50	5,270	5,390
			100	6,430	6,480
			200	8,010	8,070
			500	9,180	9,210
Berryessa Creek at North Abel Street Below Confluence with Wrigley-Ford Ditch	19.4	B25	2	1,500	1,620
			5	2,320	2,420
			10	2,730	2,850
			25	3,900	3,980
			50	4,620	4,710
			100	5,580	5,610
			200	6,870	6,910
			500	8,140	8,190
Berryessa Creek Berryessa Pump Station	17.8	B23	2	1,300	1,370
			5	2,040	2,140
			10	2,460	2,550
			25	3,540	3,610
			50	4,280	4,380
			100	5,250	5,280
			200	6,470	6,490
			500	7,600	7,630
Berryessa Creek Below Confluence with Tularcitos Creek	17.3	B21	2	1,210	1,280
			5	1,940	2,020
			10	2,330	2,410
			25	3,490	3,550
			50	4,180	4,280
			100	5,250	5,260
			200	6,190	6,230
			500	7,250	7,310

Table 15. 24-Hour Storm Flood Frequency Quantiles (Cont.)

Location	Drainage Area (sq mi)	HMS Node	Recurrence Interval (yrs)	Existing Conditions (cfs)	Future Conditions (cfs)
Berryessa Creek at Calaveras Boulevard	15.10	B19	2	1,030	1,090
			5	1,670	1,730
			10	1,990	2,050
			25	2,950	3,040
			50	3,650	3,740
			100	4,690	4,700
			200	5,440	5,490
			500	6,430	6,480
Berryessa Creek Below Confluence with Piedmont Creek	11.2	B17	2	780	840
			5	1,290	1,350
			10	1,550	1,600
			25	2,400	2,450
			50	2,930	2,990
			100	3,780	3,800
			200	4,490	4,520
			500	5,180	5,230
Berryessa Creek at Yosemite Rd	9.20	B15	2	580	620
			5	960	990
			10	1,130	1,170
			25	1,730	1,770
			50	2,150	2,200
			100	2,890	2,910
			200	3,550	3,580
			500	4,240	4,290
Berryessa Creek at Landess Road	8.91	B13	2	590	610
			5	940	960
			10	1,080	1,120
			25	1,580	1,620
			50	1,970	2,020
			100	2,770	2,780
			200	3,450	3,490
			500	4,150	4,200
Berryessa Creek Below Confluence with Sierra Creek (Morrill Rd)	7.70	B11	2	440	470
			5	680	710
			10	790	830
			25	1,210	1,260
			50	1,600	1,630
			100	2,100	2,140
			200	2,630	2,660
			500	3,090	3,140
Berryessa Creek Below Confluence with Crosley Creek	5.75	B9	2	280	300
			5	480	500
			10	650	700
			25	970	1,000
			50	1,300	1,340
			100	1,700	1,740
			200	2,190	2,220
			500	2,580	2,600

Table 15. 24-Hour Storm Flood Frequency Quantiles (Cont.)

Location	Drainage Area (sq mi)	HMS Node	Recurrence Interval (yrs)	Existing Conditions (cfs)	Future Conditions (cfs)
Berryessa Creek	4.91	B7	2	230	260
Below Confluence with			5	420	450
Sweigert Creek			10	570	600
			25	850	890
			50	1,150	1,180
			100	1,500	1,530
			200	1,940	1,960
			500	2,270	2,300
Berryessa Creek at	4.40	B5	2	220	240
Old Piedmont Road			5	390	420
			10	530	560
			25	790	830
			50	1,060	1,090
			100	1,400	1,430
			200	1,800	1,820
			500	2,110	2,130

Table 16. Regression Equation Analysis

Basin ID	Slope (ft/ft)	Drainage Area (mi^2)	Basin Length (mi)	Mean Annual Precip (MAP) (in)	100-Year Peak Flow (Q_{100}) (cfs)	90% Confidence Lower Limit (cfs)	90% Confidence Upper Limit (cfs)	Existing Q_{100} (from HMS) (cfs)
B5	0.0754	4.40	5.02	19	608	277	1,335	1,398
B2	0.0667	1.03	2.04	21	273	109	681	352
CAL2	0.1302	2.49	2.35	19	357	136	784	728

Table 17. Flood Frequency Analysis At Two Gage Stations

Gage	10-Year Q_{10} (cfs)	100-Year Q_{100} (cfs)	Area (mi^2)	Q_{100} / Area (cfs/mi^2)
SCVWD Station 64	2,260	4,610	15.1	305
USGS Station 11172100	1,811	4,416	21.5	205

Table 18. Comparison of Peak Flows with Other Berryessa Creek Studies

Location	10-year Recurrence			100-year Recurrence		
	COE 1982 (cfs)	SCVWD 1978 (cfs)	nhc 2003 (cfs)	COE 1982 (cfs)	SCVWD 1978 (cfs)	nhc 2003 (cfs)
at Old Piedmont Road	640	700	530	1,570	1,580	1,400
Below Piedmont Creek	1,610	1,720	1,550	3,420	2,980	3,780
at Calaveras Boulevard	2,150	2,270	1,990	4,780	4,020	4,690

Table 19. 72-Hour Rainfall Distribution

Time (hrs)	% of Storm Total	Time (hrs)	% of Storm Total	Time (hrs)	% of Storm Total
1	0.00	25	3.12	49	0.00
2	0.85	26	4.63	50	0.00
3	1.76	27	3.36	51	0.78
4	3.88	28	1.34	52	2.54
5	3.50	29	1.35	53	1.96
6	3.88	30	1.14	54	2.35
7	4.10	31	0.39	55	2.54
8	3.88	32	0.14	56	2.26
9	1.76	33	0.42	57	1.05
10	1.06	34	1.31	58	0.39
11	0.99	35	1.88	59	0.31
12	0.49	36	1.54	60	0.08
13	0.14	37	1.36	61	0.00
14	0.35	38	2.15	62	0.00
15	0.00	39	5.14	63	0.00
16	0.00	40	5.68	64	0.00
17	0.00	41	5.95	65	0.00
18	0.00	42	3.64	66	0.00
19	0.00	43	2.63	67	0.00
20	0.00	44	2.32	68	0.00
21	0.07	45	3.12	69	0.04
22	0.21	46	3.26	70	0.12
23	0.07	47	1.72	71	0.04
24	0.00	48	0.94	72	0.00

Table 20. 72-Hour Precipitation Totals

Region	72-Hour Precipitation Depth (inches)							
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Upper Penitencia	3.50	4.78	5.42	7.01	7.66	8.84	9.67	10.92
Upper Berryessa	3.94	5.42	6.08	8.04	8.87	10.19	11.19	12.64
Foothills	4.43	6.08	7.23	9.19	9.85	11.64	12.71	14.38

Table 21. 72-Hour Storm Loss Rate Parameters

Subbasin	2-25 Yr Basin Model		50-100 Yr Basin Model		200-500 Yr Basin Model	
	Initial Loss	Constant Loss	Initial Loss	Constant Loss	Initial Loss	Constant Loss
B12	0.23	0.106	0.18	0.090	0.09	0.045
B14	0.23	0.106	0.18	0.090	0.09	0.045
B16	0.23	0.106	0.18	0.090	0.09	0.045
B18	0.23	0.106	0.18	0.090	0.09	0.045
B20	0.23	0.106	0.18	0.090	0.09	0.045
CAL4	0.23	0.106	0.18	0.090	0.09	0.045
CAL6	0.23	0.106	0.18	0.090	0.09	0.045
CAL8	0.23	0.106	0.18	0.090	0.09	0.045
CR4	0.23	0.106	0.18	0.090	0.09	0.045
F2	0.23	0.106	0.18	0.090	0.09	0.045
LC8	0.23	0.106	0.18	0.090	0.09	0.045
LP2	0.23	0.106	0.18	0.090	0.09	0.045
LP4	0.23	0.106	0.18	0.090	0.09	0.045
LP6	0.23	0.106	0.18	0.090	0.09	0.045
LP8	0.23	0.106	0.18	0.090	0.09	0.045
LP10	0.23	0.106	0.18	0.090	0.09	0.045
LP12	0.23	0.106	0.18	0.090	0.09	0.045
LP14	0.23	0.106	0.18	0.090	0.09	0.045
LP16	0.23	0.106	0.18	0.090	0.09	0.045
W4	0.23	0.106	0.18	0.090	0.09	0.045
P4	0.32	0.161	0.27	0.135	0.18	0.090
SIE4	0.32	0.161	0.27	0.135	0.18	0.090
SW4	0.32	0.161	0.27	0.135	0.18	0.090
T4	0.32	0.161	0.27	0.135	0.18	0.090
B2	0.54	0.225	0.45	0.180	0.24	0.135
B4	0.54	0.225	0.45	0.180	0.24	0.135
B6	0.54	0.225	0.45	0.180	0.24	0.135
B8	0.54	0.225	0.45	0.180	0.24	0.135
B10	0.54	0.225	0.45	0.180	0.24	0.135
CAL2	0.54	0.225	0.45	0.180	0.24	0.135
CR2	0.54	0.225	0.45	0.180	0.24	0.135
LC2	0.54	0.225	0.45	0.180	0.24	0.135
LC4	0.54	0.225	0.45	0.180	0.24	0.135
LC6	0.54	0.225	0.45	0.180	0.24	0.135
P2	0.54	0.225	0.45	0.180	0.24	0.135
SIE2	0.54	0.225	0.45	0.180	0.24	0.135
ST2	0.54	0.225	0.45	0.180	0.24	0.135
SW2	0.54	0.225	0.45	0.180	0.24	0.135
T2	0.54	0.225	0.45	0.180	0.24	0.135

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Figure 1. Berryessa Creek Study Area

Figure 2. Subbasin Boundaries

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Figure 5. Existing Land-Use Map

Figure 6. Future Land-Use Map

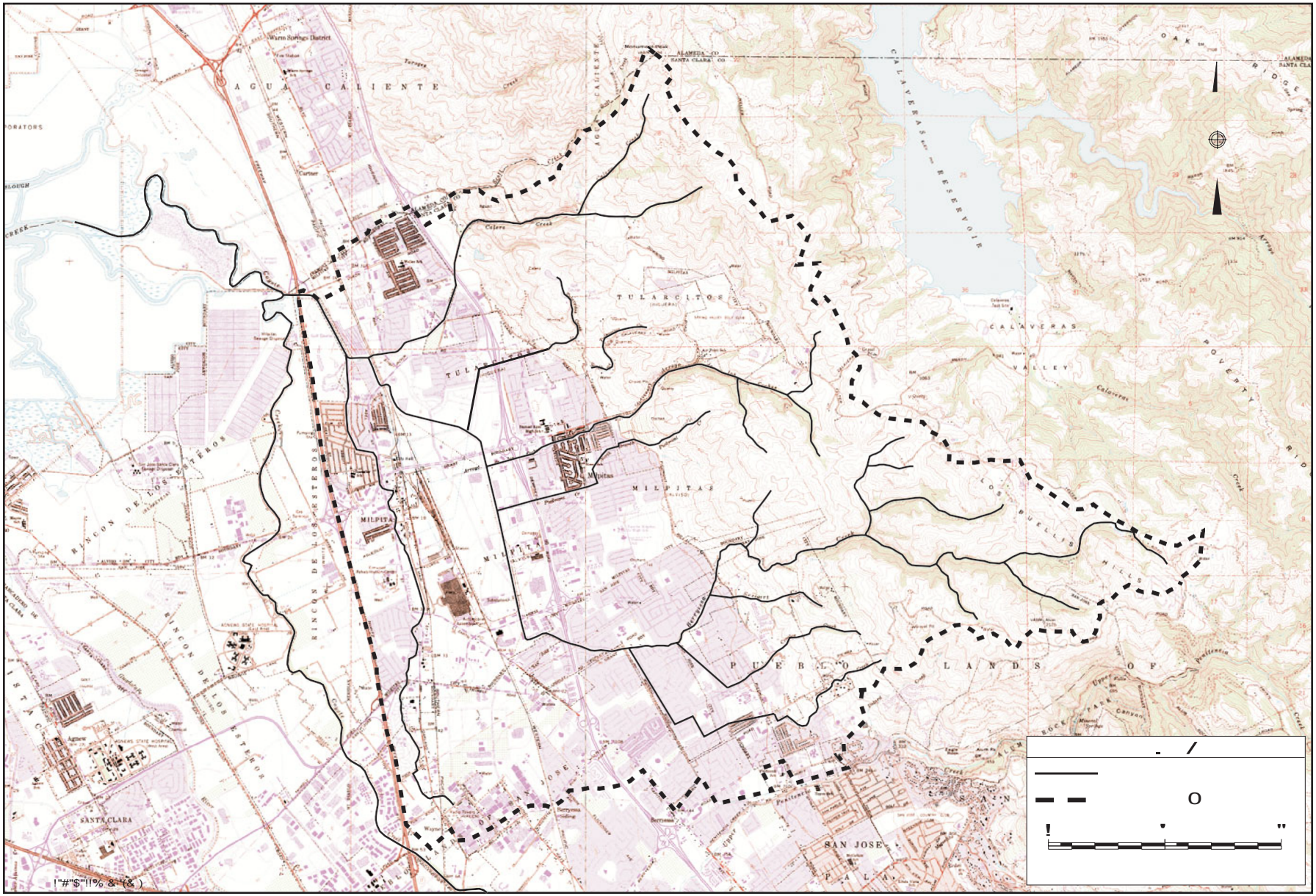
Figure 7. HEC-HMS Flow Connection Schematic

Figure 8. 24-Hour, 100-Year Hydrograph: Berryessa Creek at Old Piedmont Road

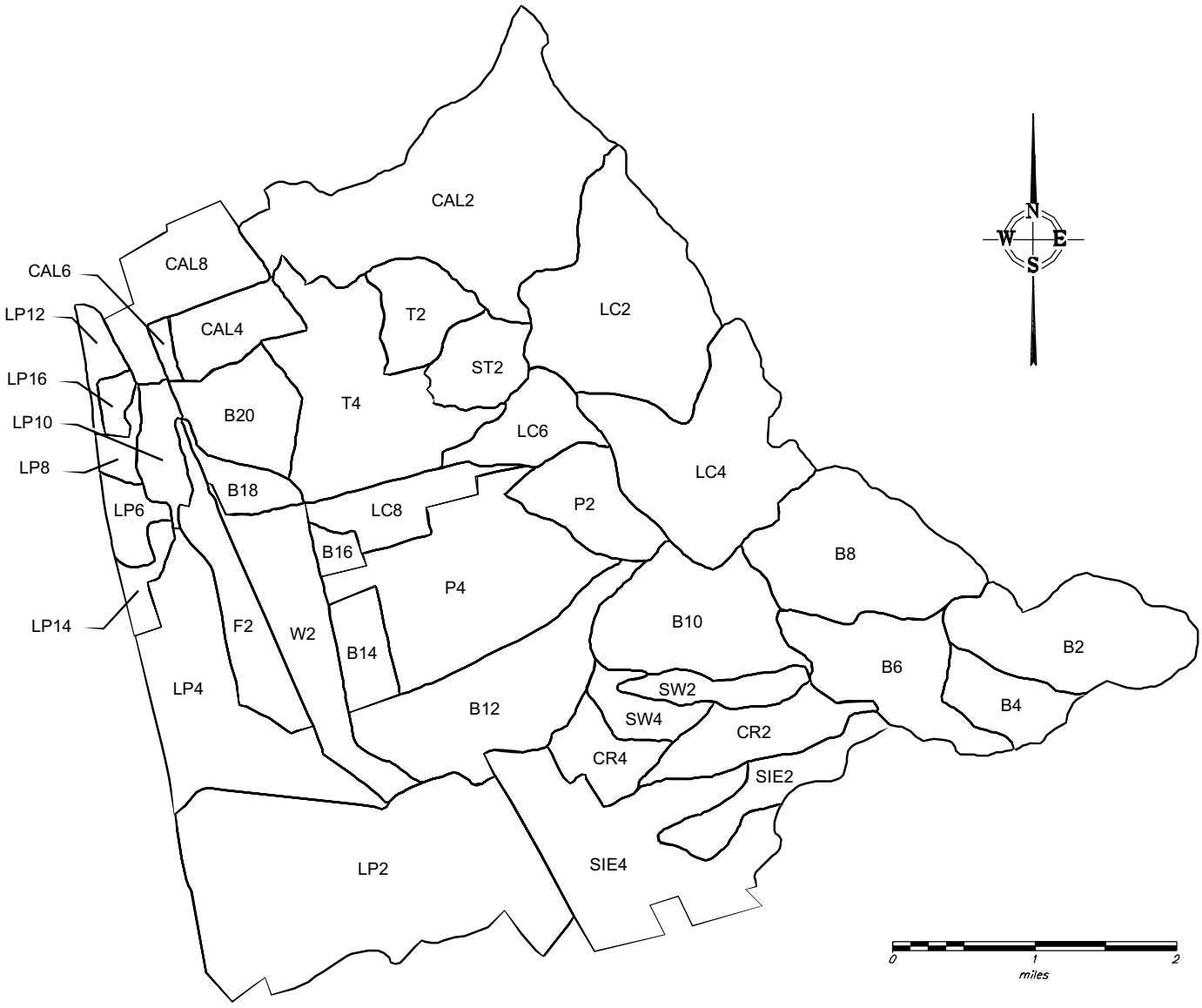
Figure 9. 24-Hour, 100-Year Hydrograph: Berryessa Creek at Calaveras Boulevard

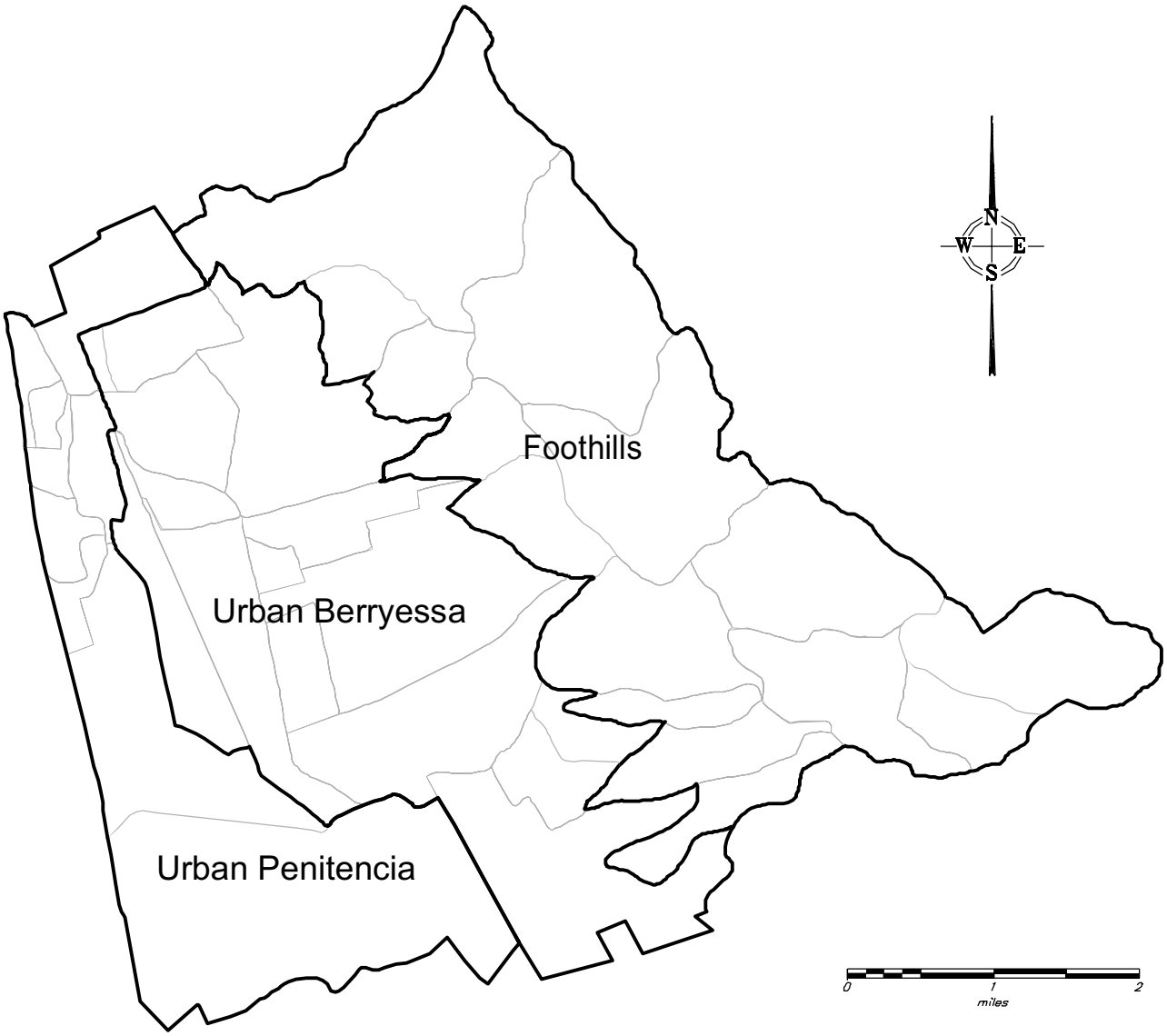
Figure 10. 72-Hour, 100-Year Hydrograph: Berryessa Creek at Old Piedmont Road

Figure 11. 72-Hour, 100-Year Hydrograph: Berryessa Creek at Calaveras Boulevard


AGUA CALIENTE
TULARCITOS
MILPITAS
CALAVERAS
VALLEY
PUEBLO LANDS OF
SAN JOSE
SANTA CLARA
RINCON DE LOS ESTEROS
Warm Springs District
Calaveras Reservoir
Penitencia Creek
Coyote Creek
Berryessa
Agnew
Milpitas
Alameda Co
Santa Clara Co

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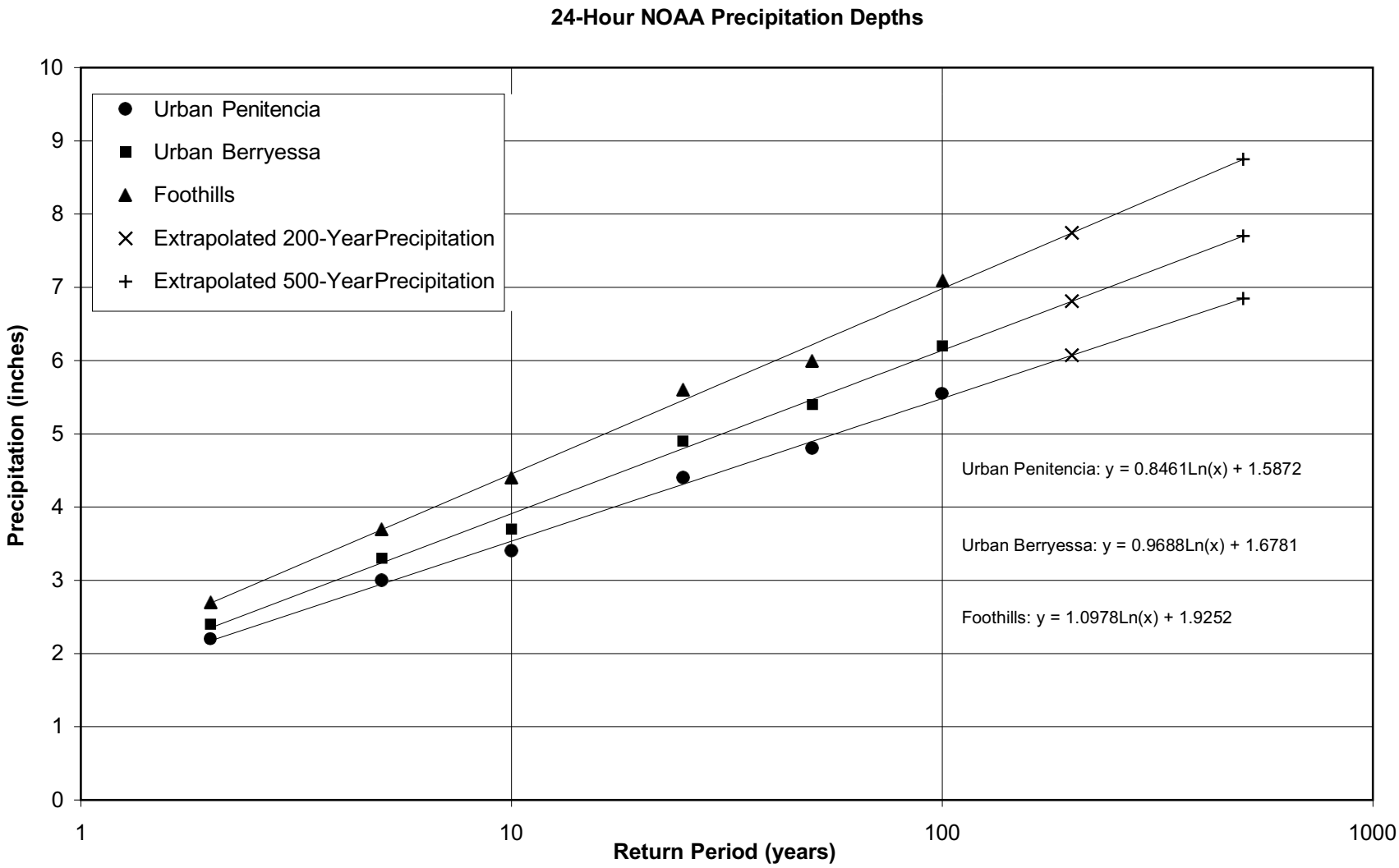

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CAL8
CAL6
LP12
CAL4
T2
LC2
LP16
ST2
T4
B20
LP10
LC6
LC4
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P2
LP6
LC8
B8
B16
P4
LP14
F2
W2
B14
B10
B2
LP4
B6
SW2
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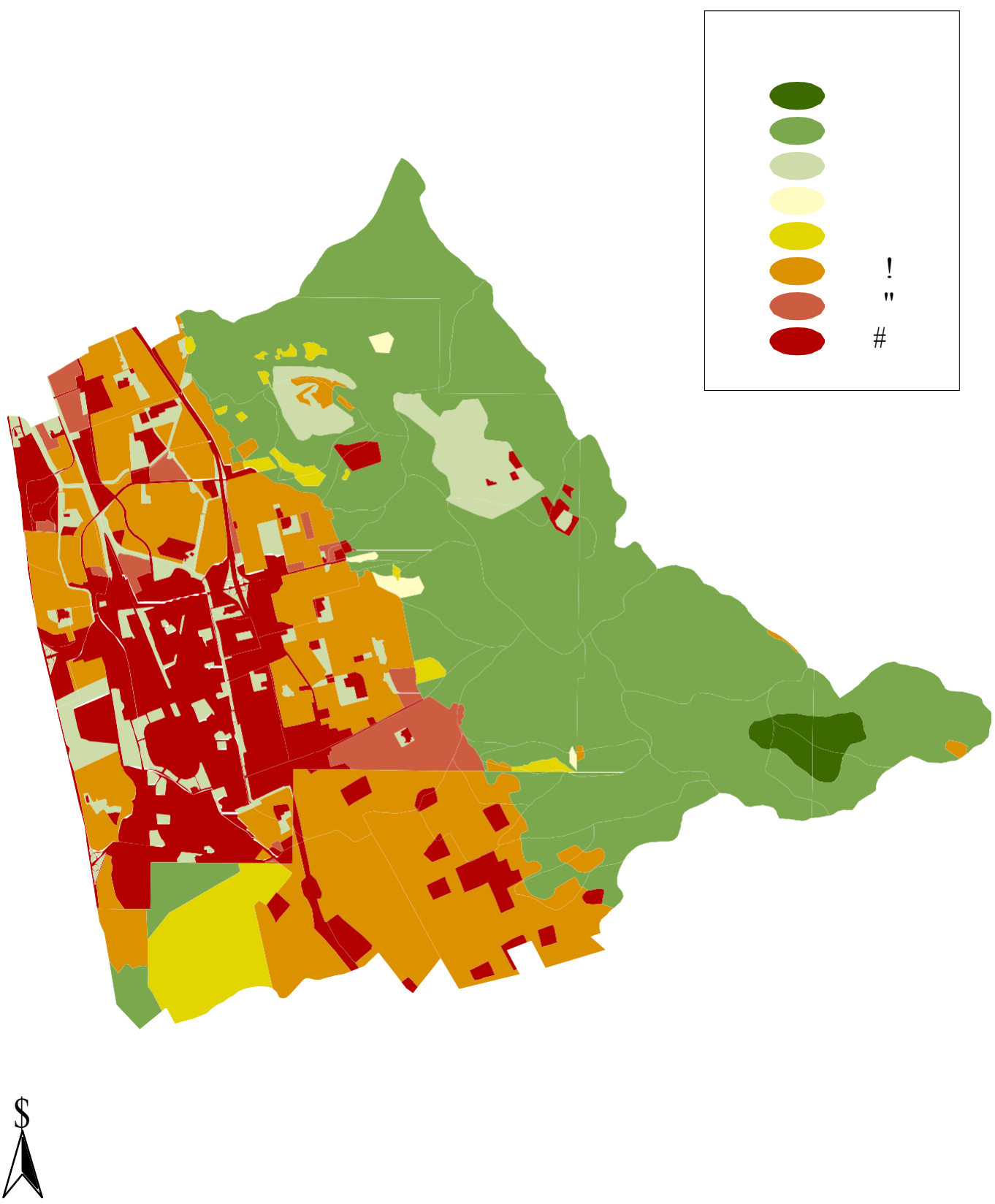
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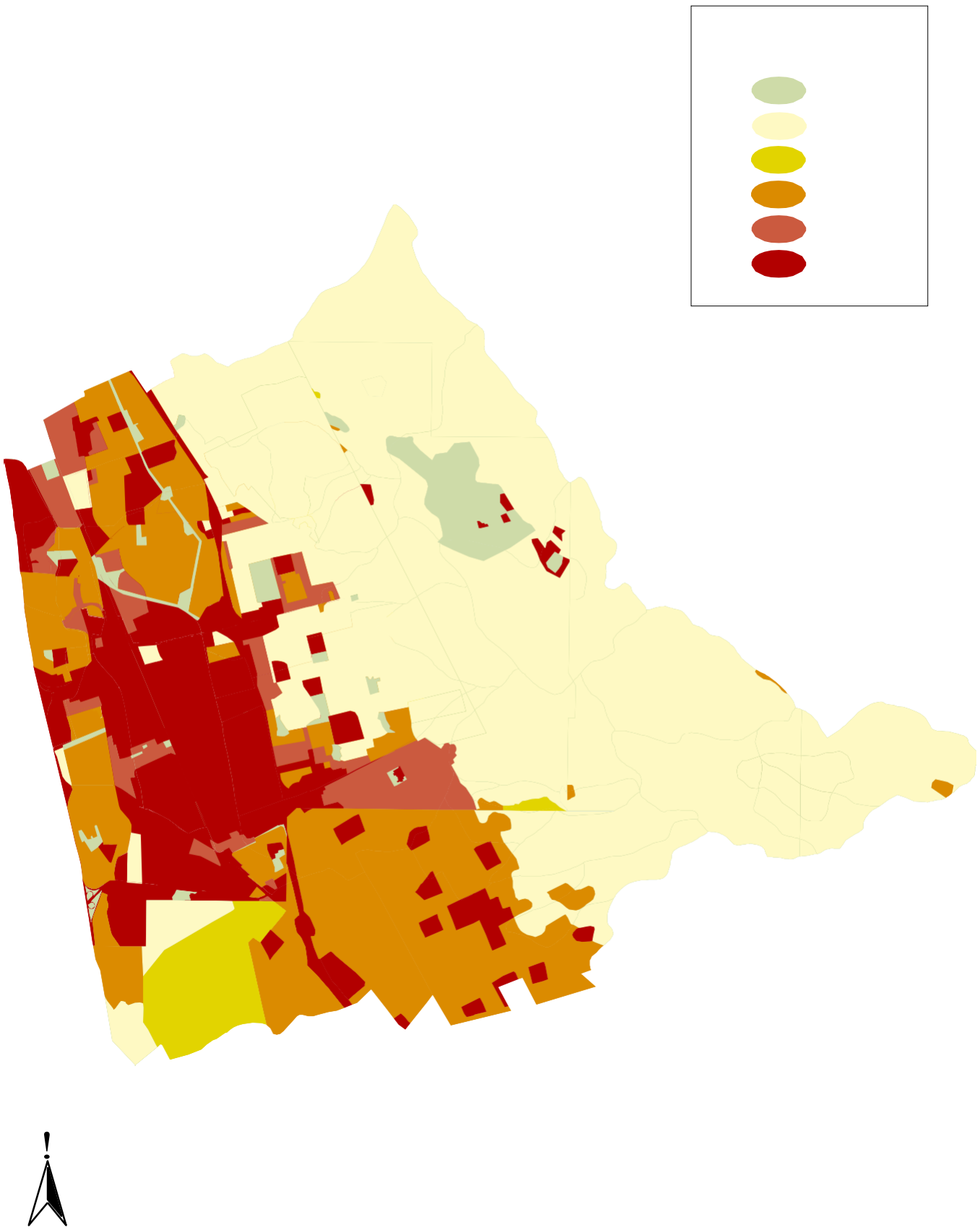
Berryessa Creek Levees Project

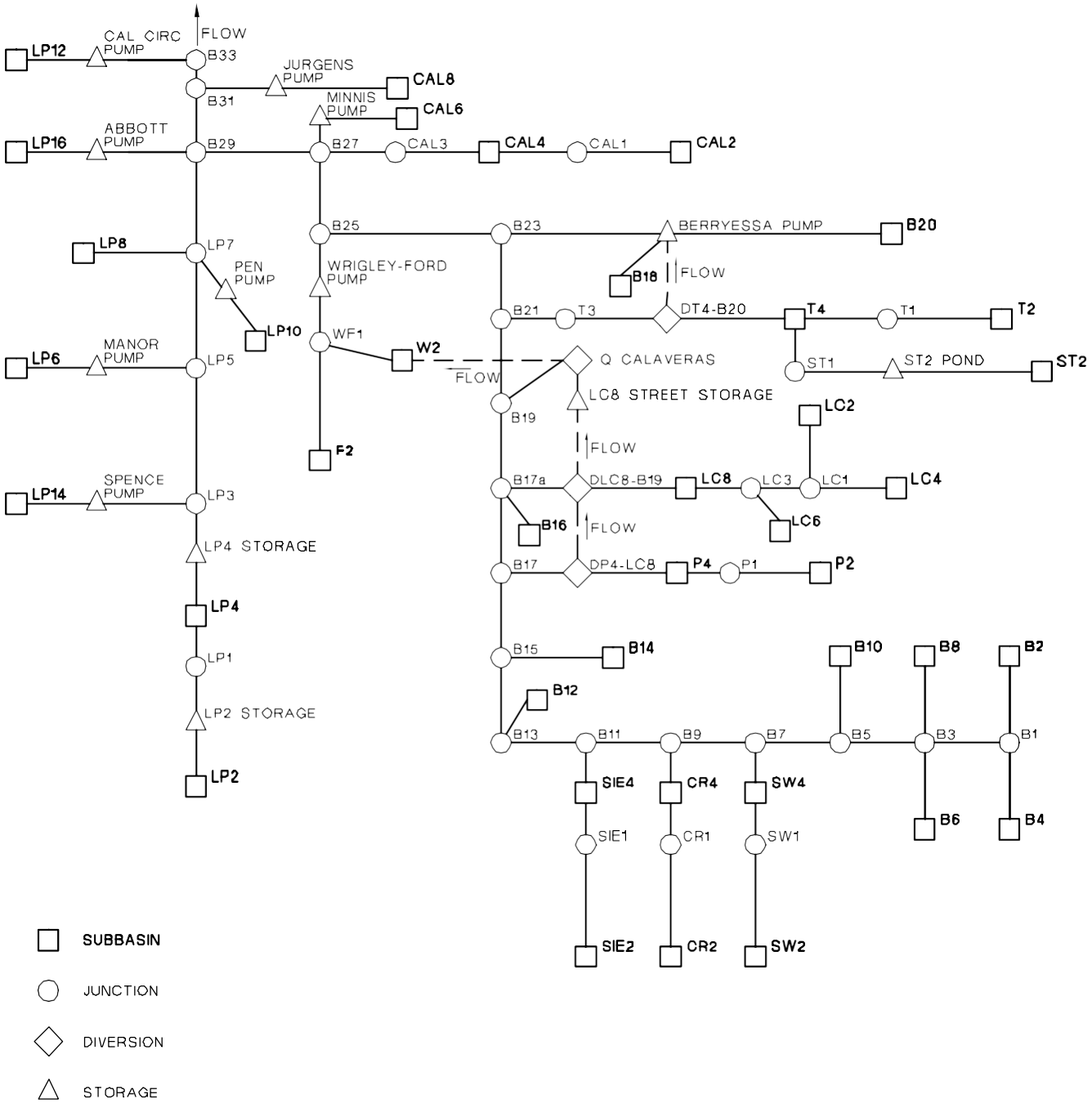
Precipitation Regions
Figure 3

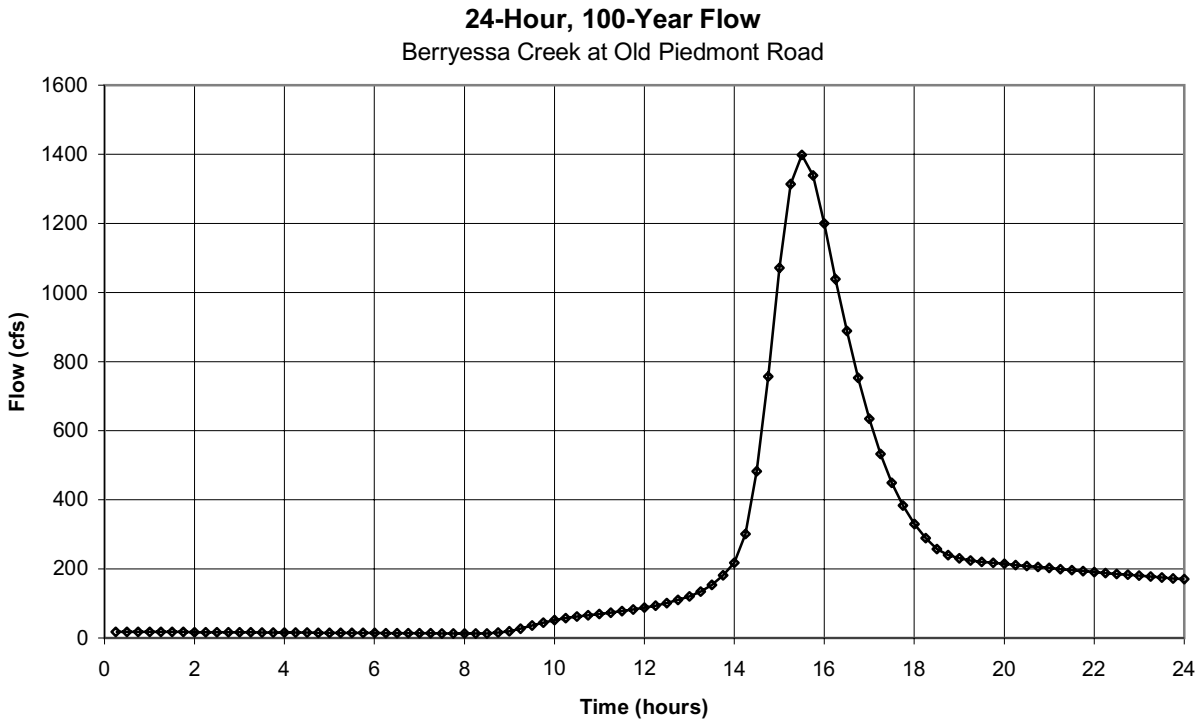


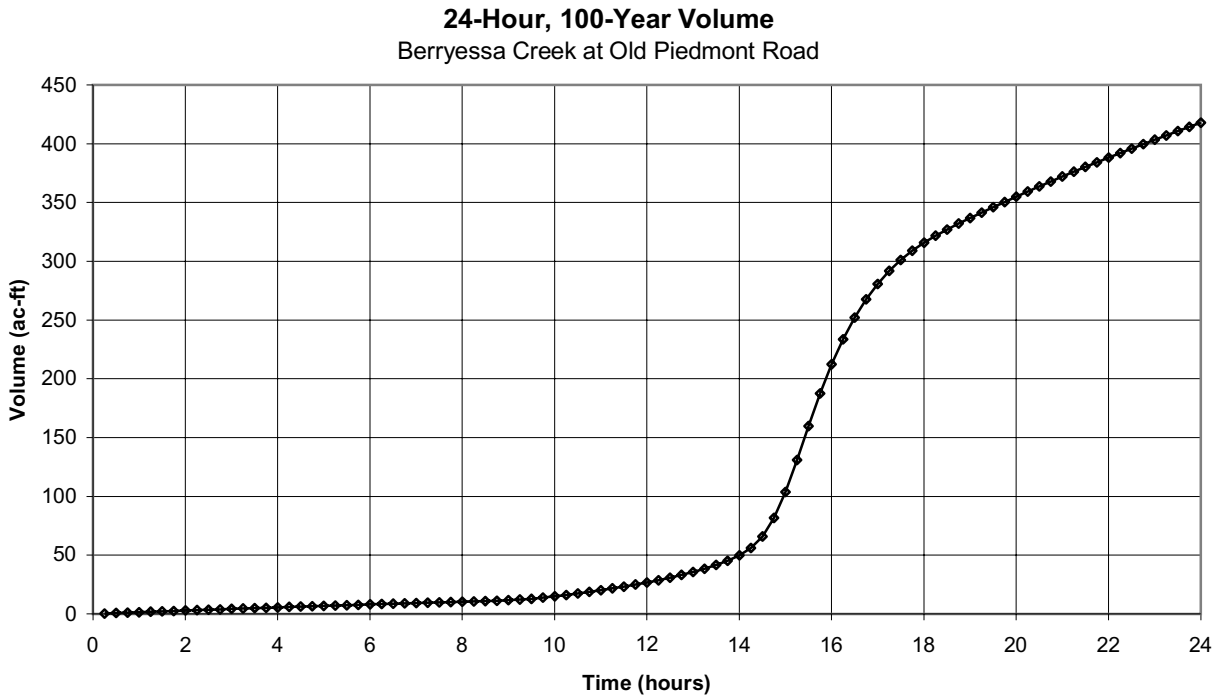
Note: Return Period axis is plotted on a log scale.

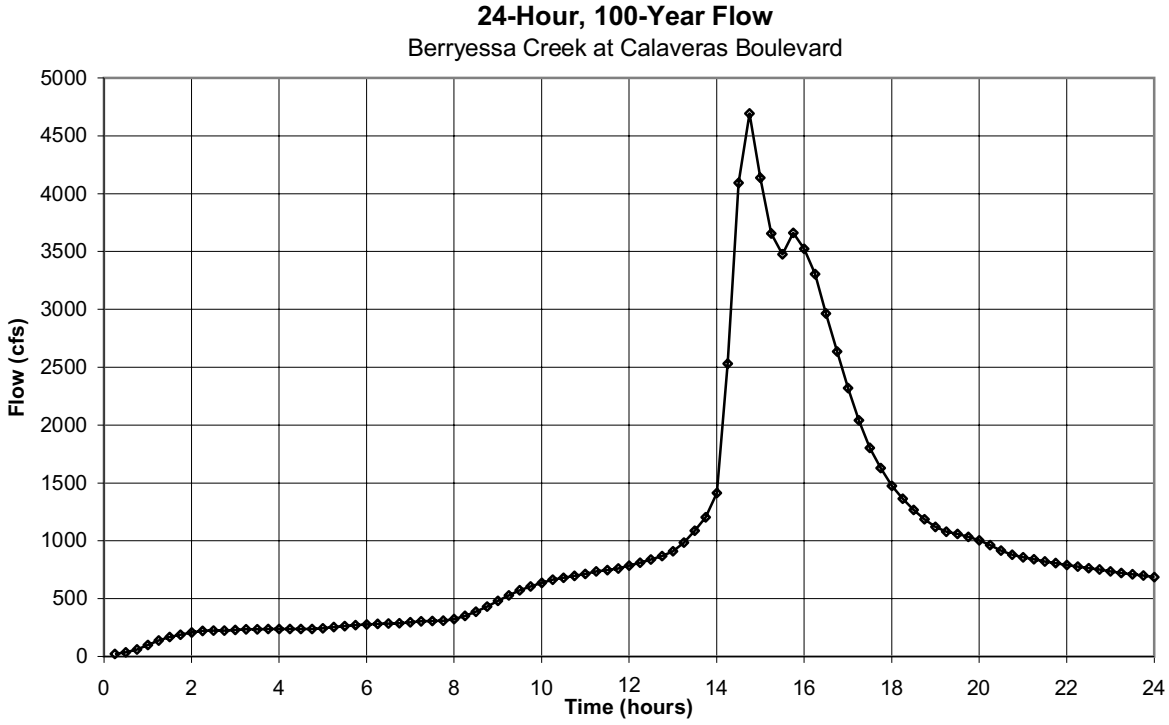


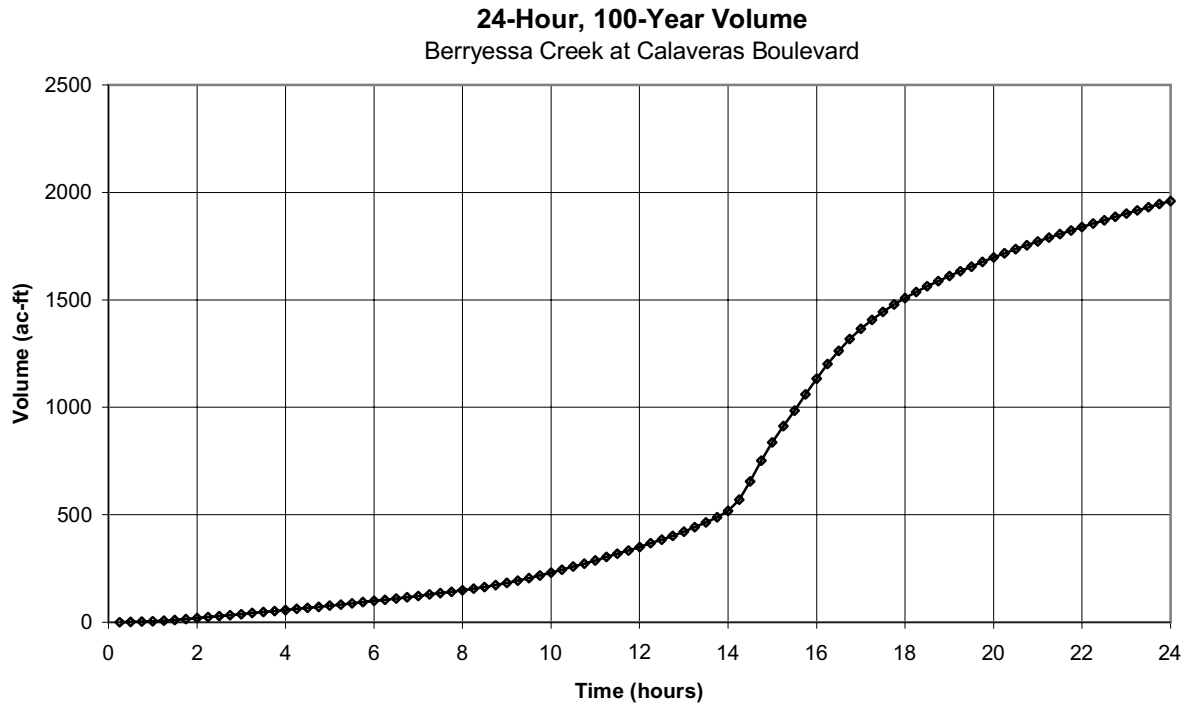


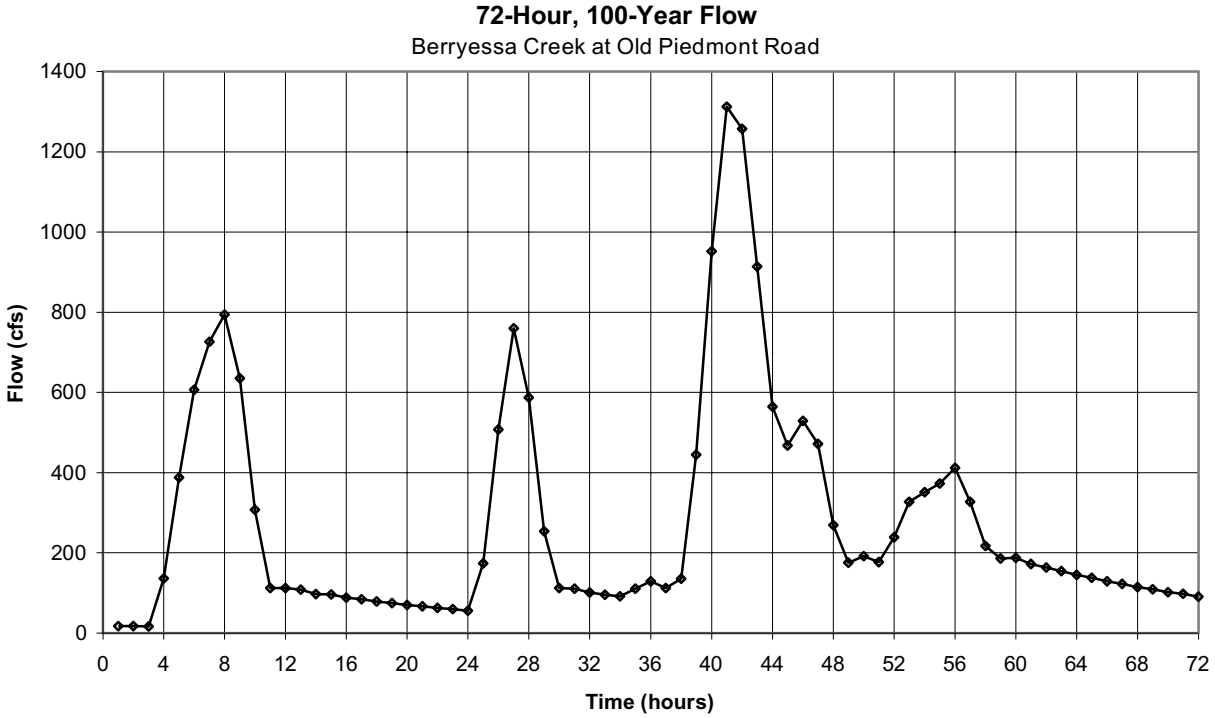

CAL CIRC PUMP
FLOW
LP12
B33
JURGENS PUMP
CAL8
B31
MINNIS PUMP
CAL6
ABBOTT PUMP
LP16
B29
B27
CAL3
CAL4
CAL1
CAL2
B25
B23
BERRYESSA PUMP
B20
LP8
LP7
PEN PUMP
WRIGLEY-FORD PUMP
B18
FLOW
B21
T3
DT4-B20
T4
T1
T2
LP10
WF1
W2
MANOR PUMP
LP6
LP5
FLOW
Q CALAVERAS
ST1
ST2 POND
ST2
LC8 STREET STORAGE
B19
LC2
F2
FLOW
SPENCE PUMP
LP14
LP3
B17a
DLC8-B19
LC8
LC3
LC1
LC4
B16
FLOW
LC6
LP4 STORAGE
B17
DP4-LC8
P4
P1
P2
LP4
B15
B14
B10
B8
B2
B12
LP1
LP2 STORAGE
B13
B11
B9
B7
B5
B3
B1
SIE4
CR4
SW4
B6
B4
SIE1
CR1
SW1
LP2
SIE2
CR2
SW2
SUBBASIN
JUNCTION
DIVERSION
STORAGE

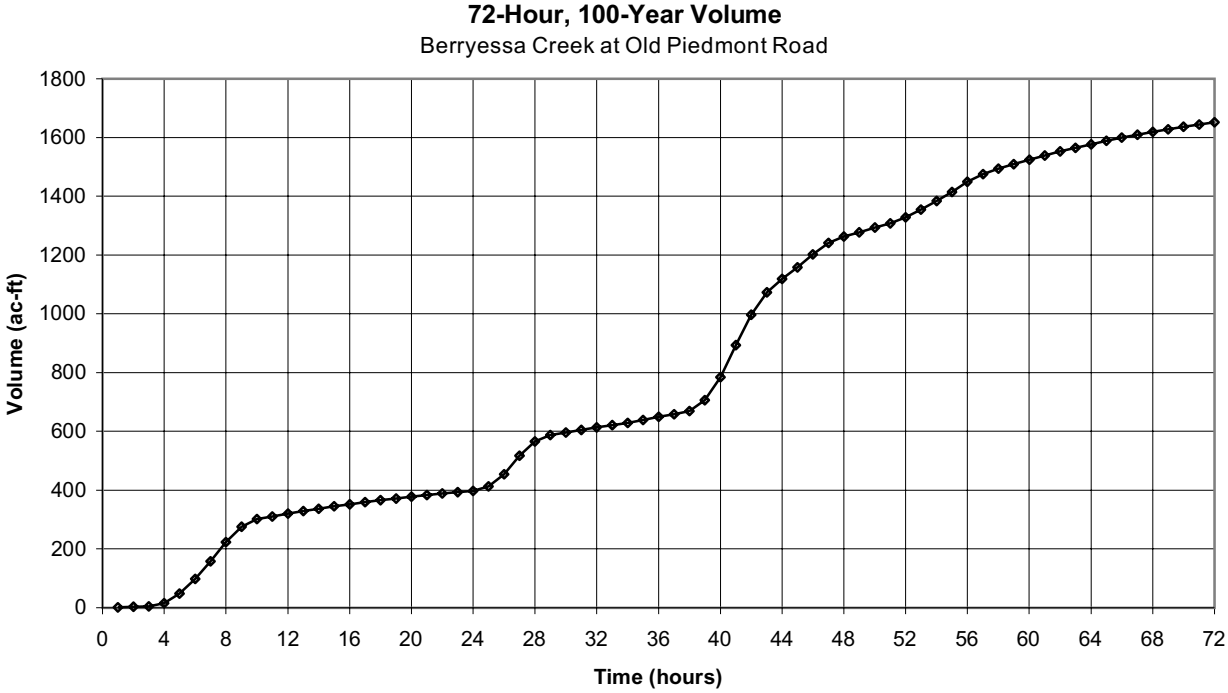

24-Hour, 100-Year Flow
Berryessa Creek at Old Piedmont Road
Flow (cfs)
0
200
400
600
800
1000
1200
1400
1600
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)

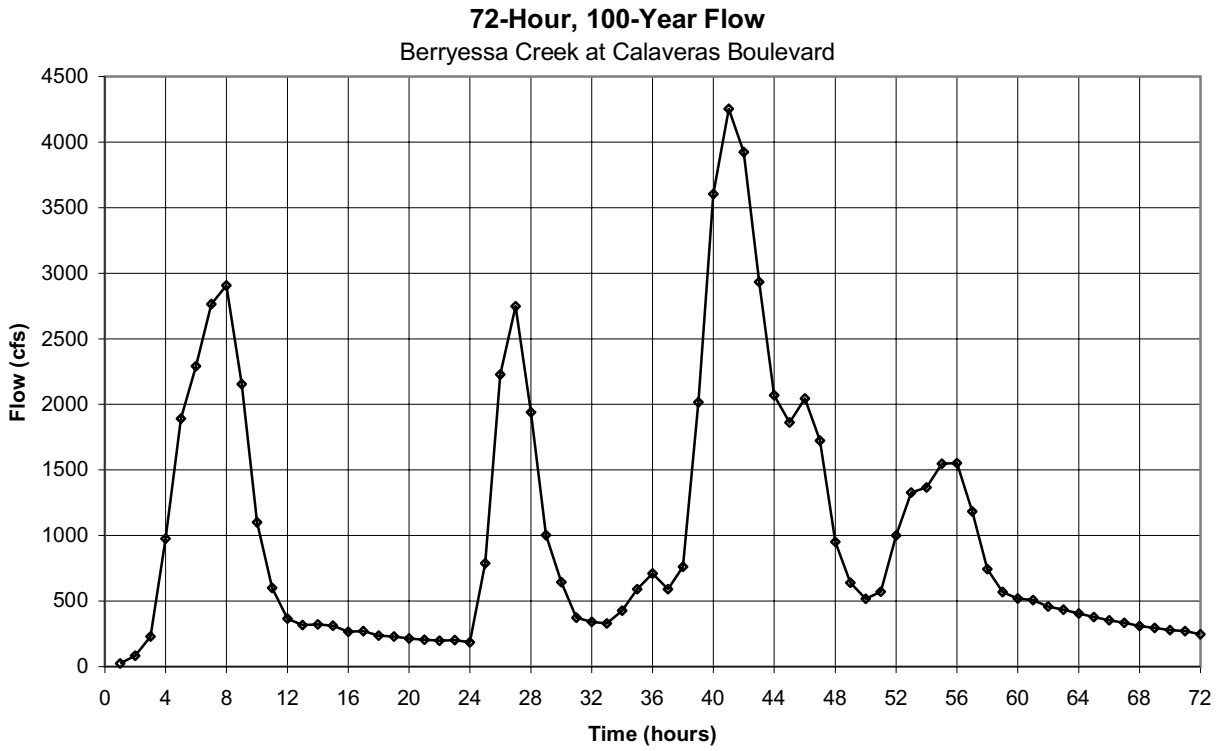

24-Hour, 100-Year Volume
Berryessa Creek at Old Piedmont Road
Volume (ac-ft)
0
50
100
150
200
250
300
350
400
450
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)

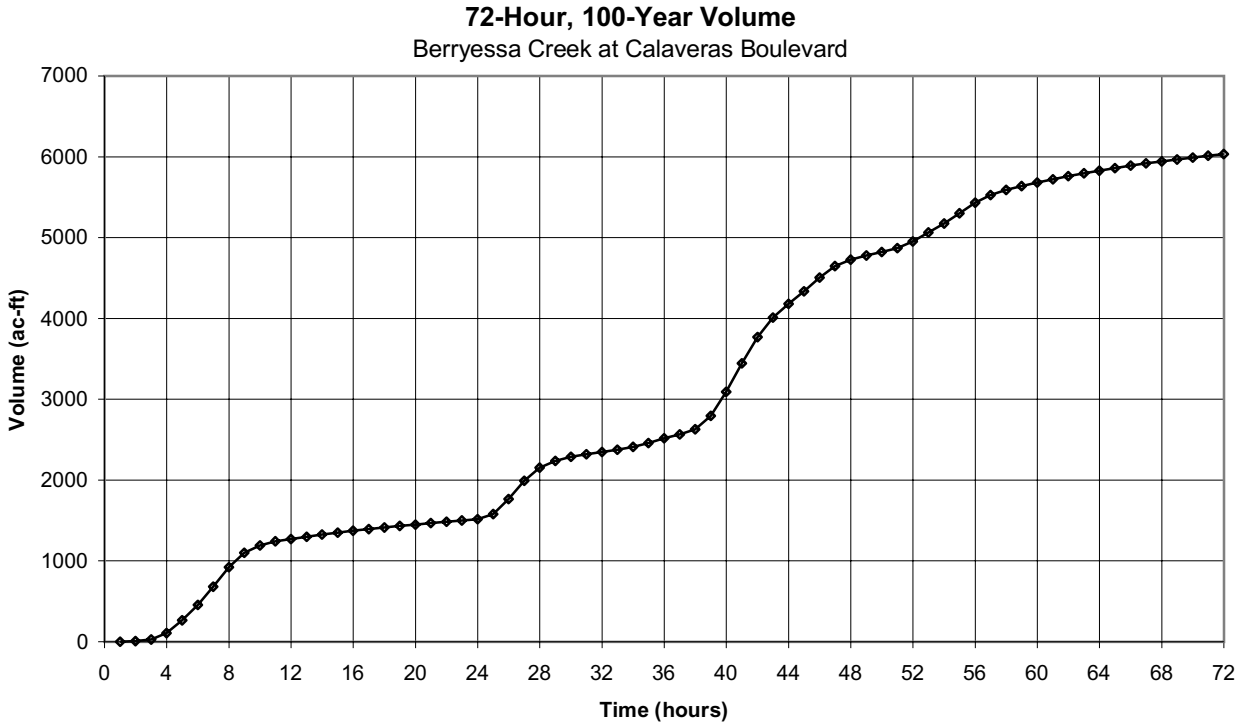

24-Hour, 100-Year Flow
Berryessa Creek at Calaveras Boulevard
Flow (cfs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)


24-Hour, 100-Year Volume
Berryessa Creek at Calaveras Boulevard
Volume (ac-ft)
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)


72-Hour, 100-Year Flow
Berryessa Creek at Old Piedmont Road
Flow (cfs)
0
200
400
600
800
1000
1200
1400
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
Time (hours)


72-Hour, 100-Year Volume
Berryessa Creek at Old Piedmont Road
Volume (ac-ft)
0
200
400
600
800
1000
1200
1400
1600
1800
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
Time (hours)


72-Hour, 100-Year Flow
Berryessa Creek at Calaveras Boulevard
Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
Time (hours)


72-Hour, 100-Year Volume
Berryessa Creek at Calaveras Boulevard
Volume (ac-ft)
0
1000
2000
3000
4000
5000
6000
7000
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
Time (hours)

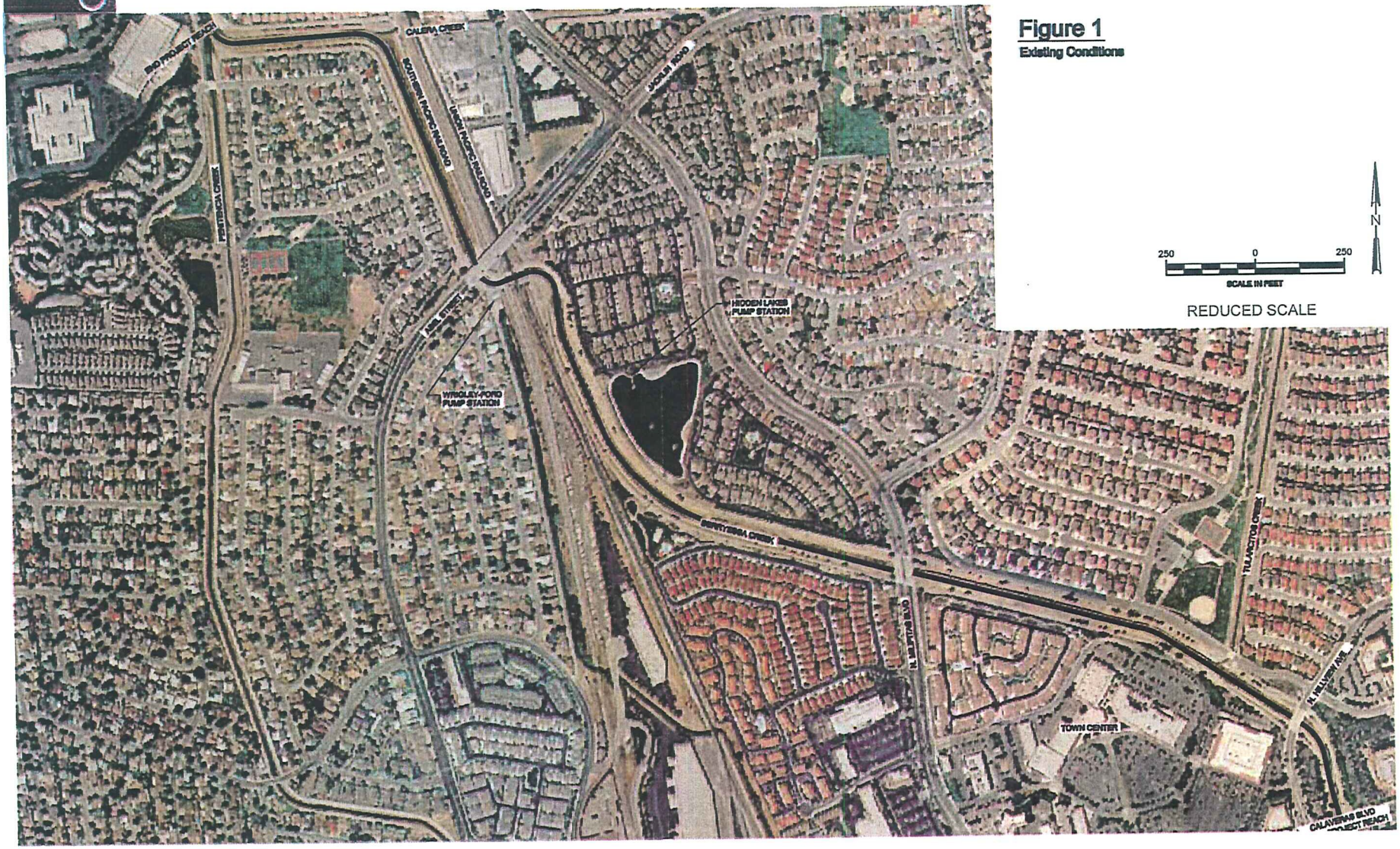
APPENDIX C - CONCEPTUAL ALTERNATIVES MATRIX

WATERSHED
Santa Clara Valley Water District

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Figure 1

Existing Conditions



REDUCED SCALE

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Figure 2

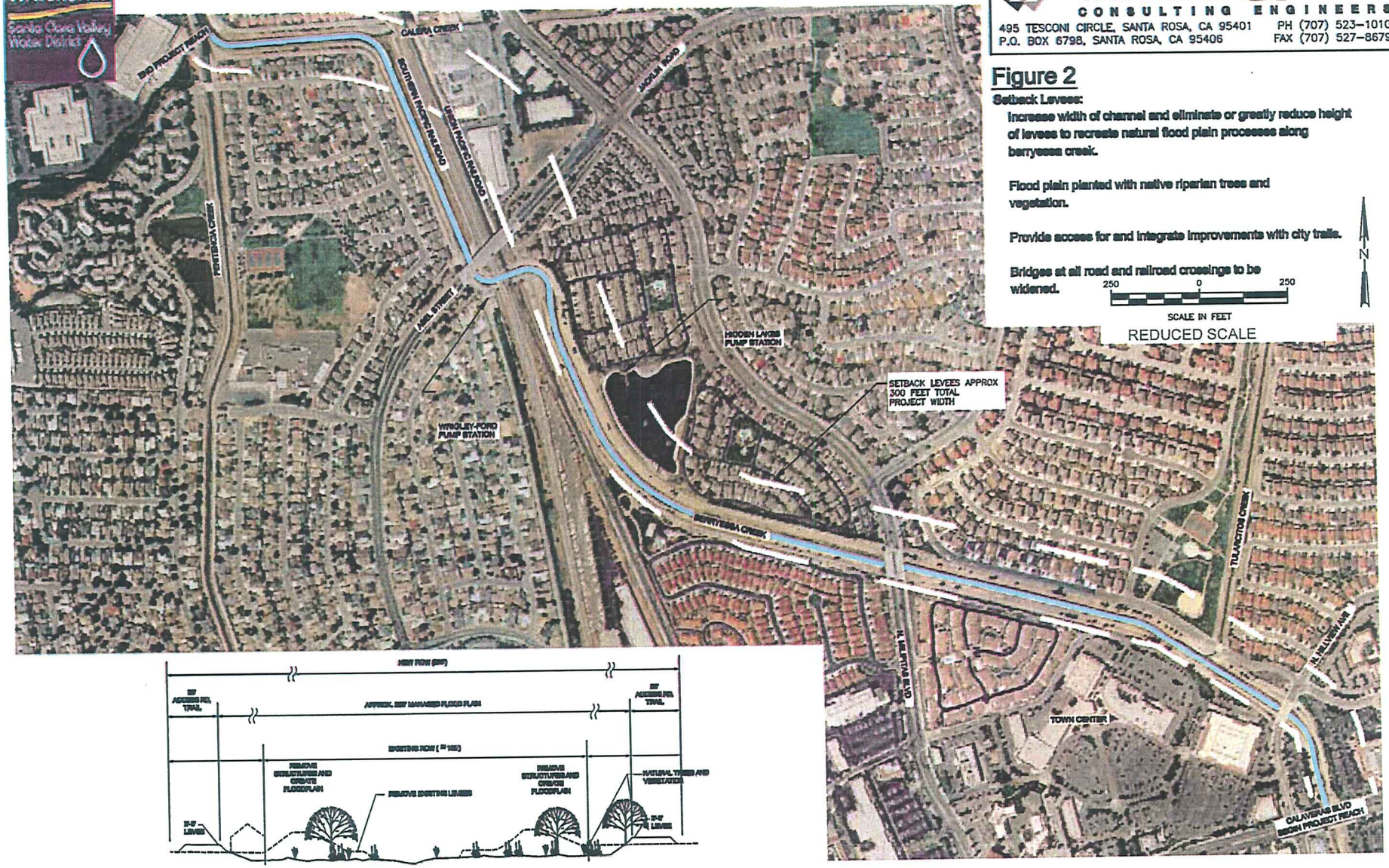
Setback Levees:

Increase width of channel and eliminate or greatly reduce height of levees to recreate natural flood plain processes along berryessa creek.

Flood plain planted with native riparian trees and vegetation.

Provide access for and integrate improvements with city trails.

Bridges at all road and railroad crossings to be widened.



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WATERSHED
Santa Clara Valley Water District

Figure 3

Raise Levees:

Raise levees in their current location within existing right-of-way and increase width of maintenance roads.

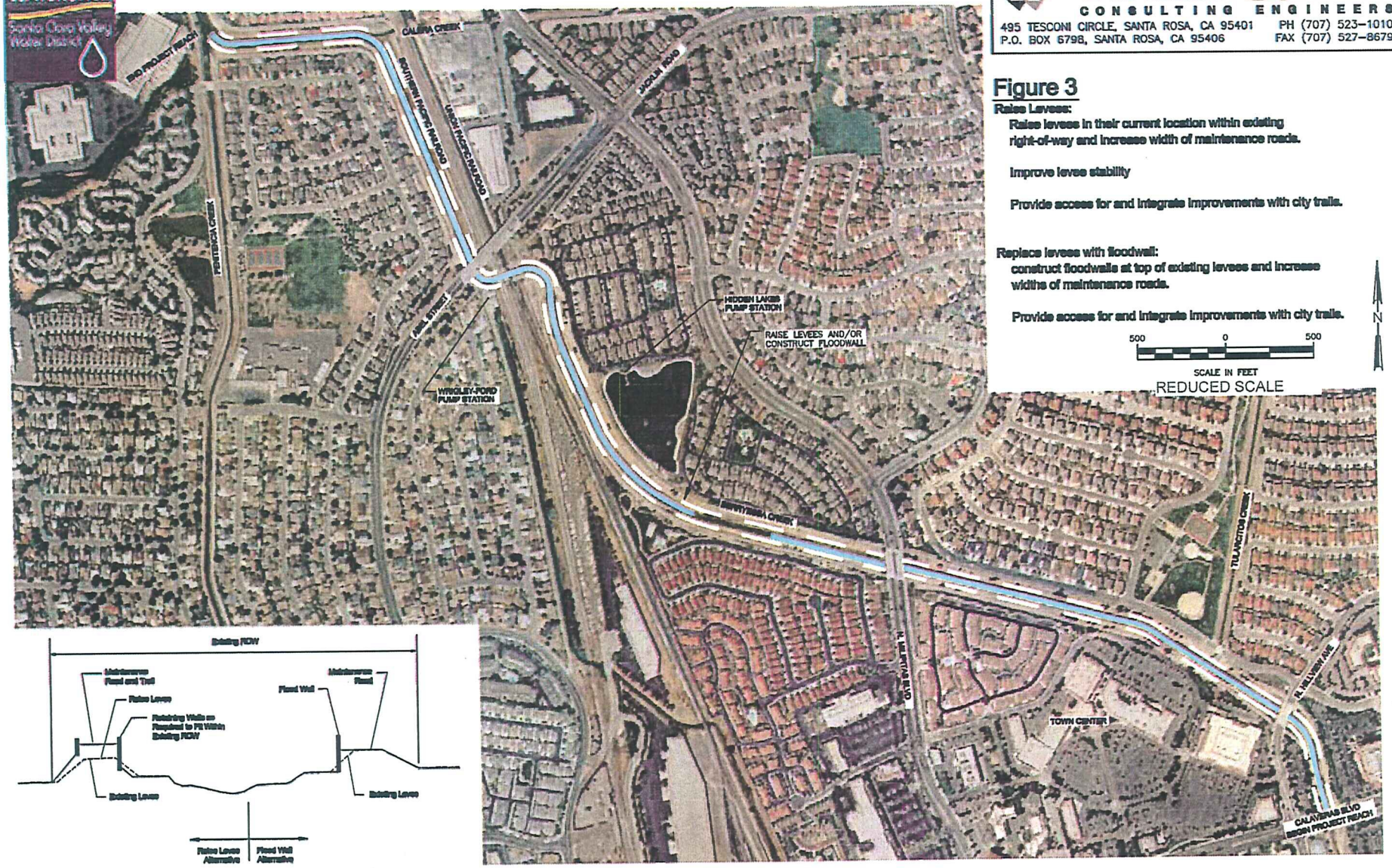
Improve levee stability

Provide access for and integrate improvements with city trails.

Replace levees with floodwall:

construct floodwalls at top of existing levees and increase widths of maintenance roads.

Provide access for and integrate improvements with city trails.



REDUCED SCALE

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Figure 4

Concrete Channel:

Replace the existing channel with a concrete-lined "u-shaped" channel

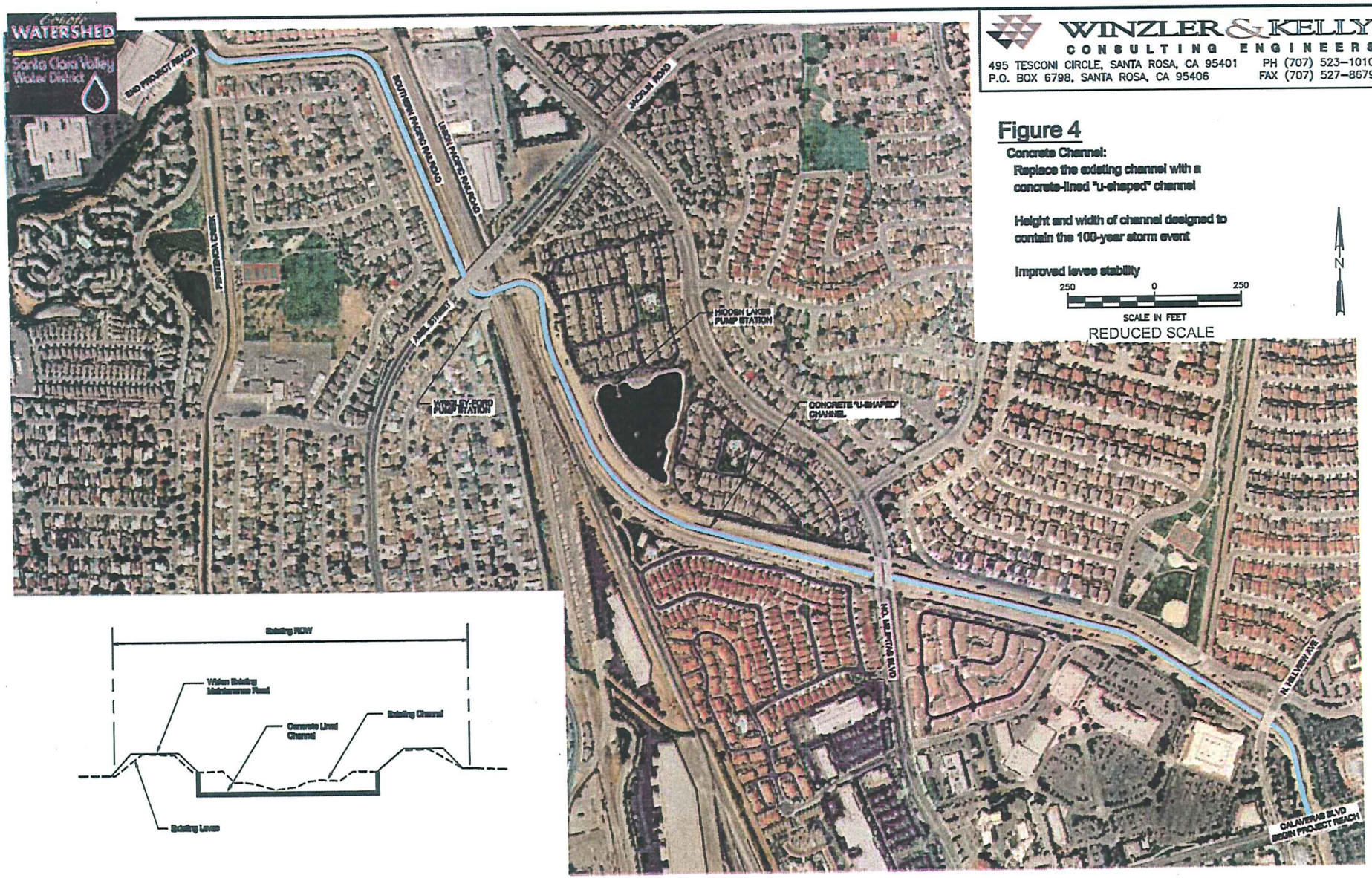
Height and width of channel designed to contain the 100-year storm event

Improved levee stability

250 0 250

SCALE IN FEET

REDUCED SCALE



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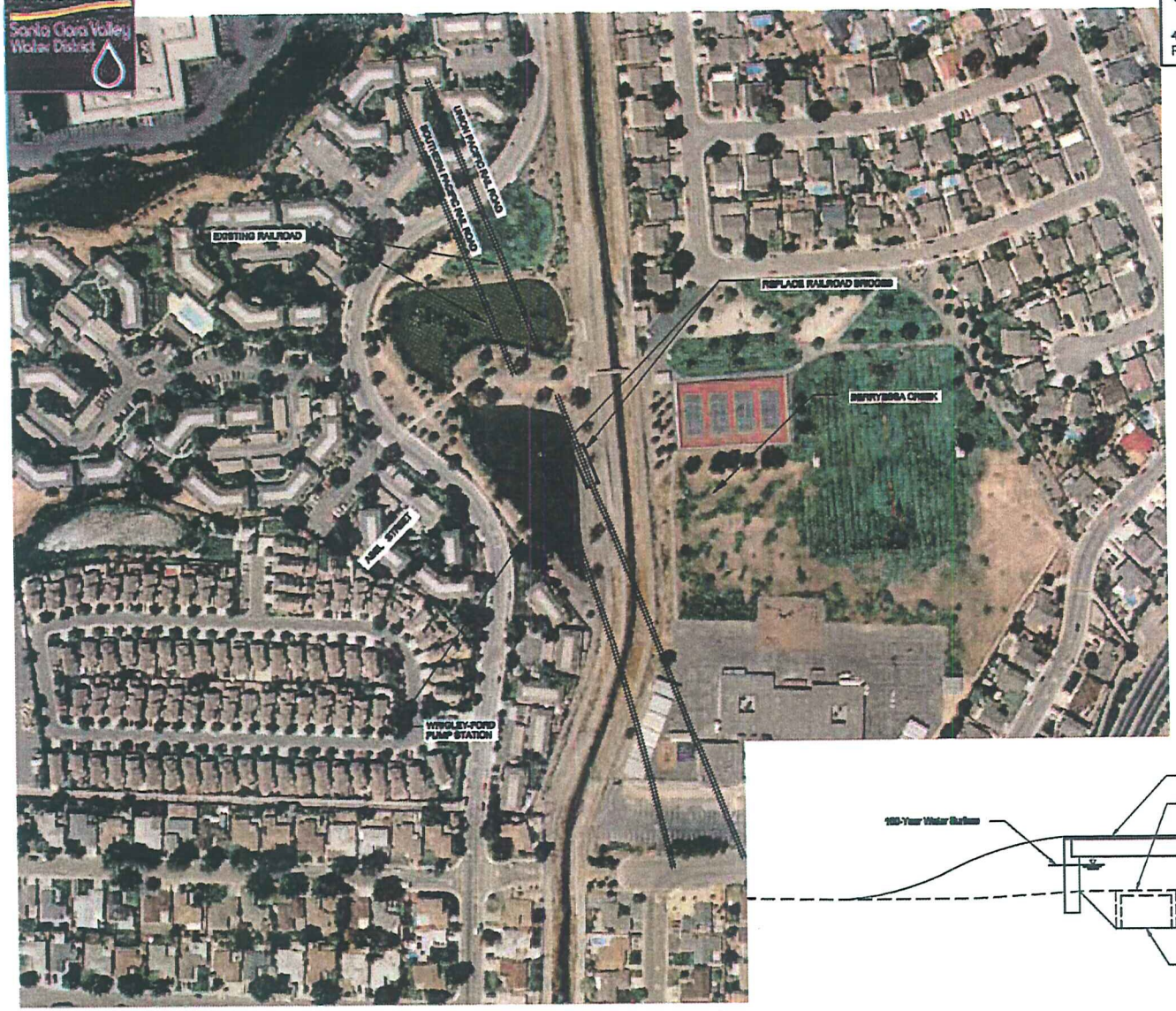
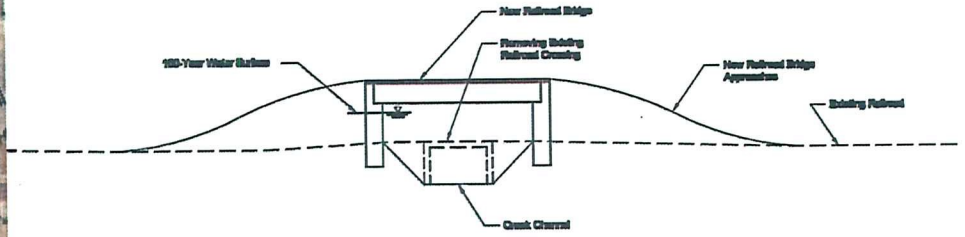


Figure 5

Replace railroad bridges:
Two existing railroad bridges removed and reconstructed above the 100-year water surface elevation.



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Figure 6

Straighten double 90 degree reach:

Remove the existing double 90 degree bend in the channel and replace with a smoother "s" curve.

Requires construction of new railroad crossing for relocated channel.

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Figure 7

Widen channel:

Widen Channel to contain 100-year flood.
Height of new levees to match existing.

Provide access for and integrate improvements with city trails.

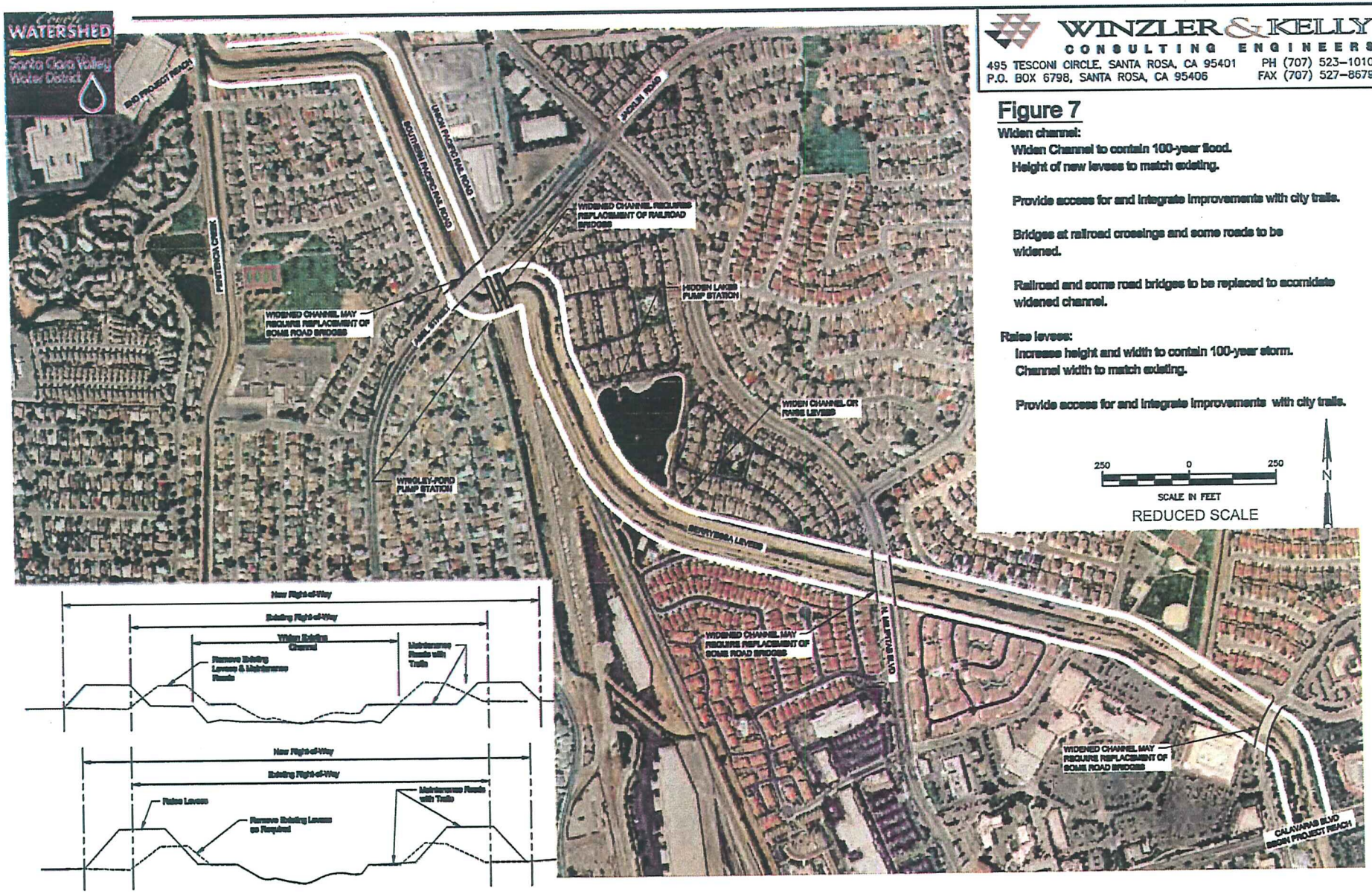
Bridges at railroad crossings and some roads to be widened.

Railroad and some road bridges to be replaced to accomidate widened channel.

Raise levees:

Increase height and width to contain 100-year storm.
Channel width to match existing.

Provide access for and integrate improvements with city trails.



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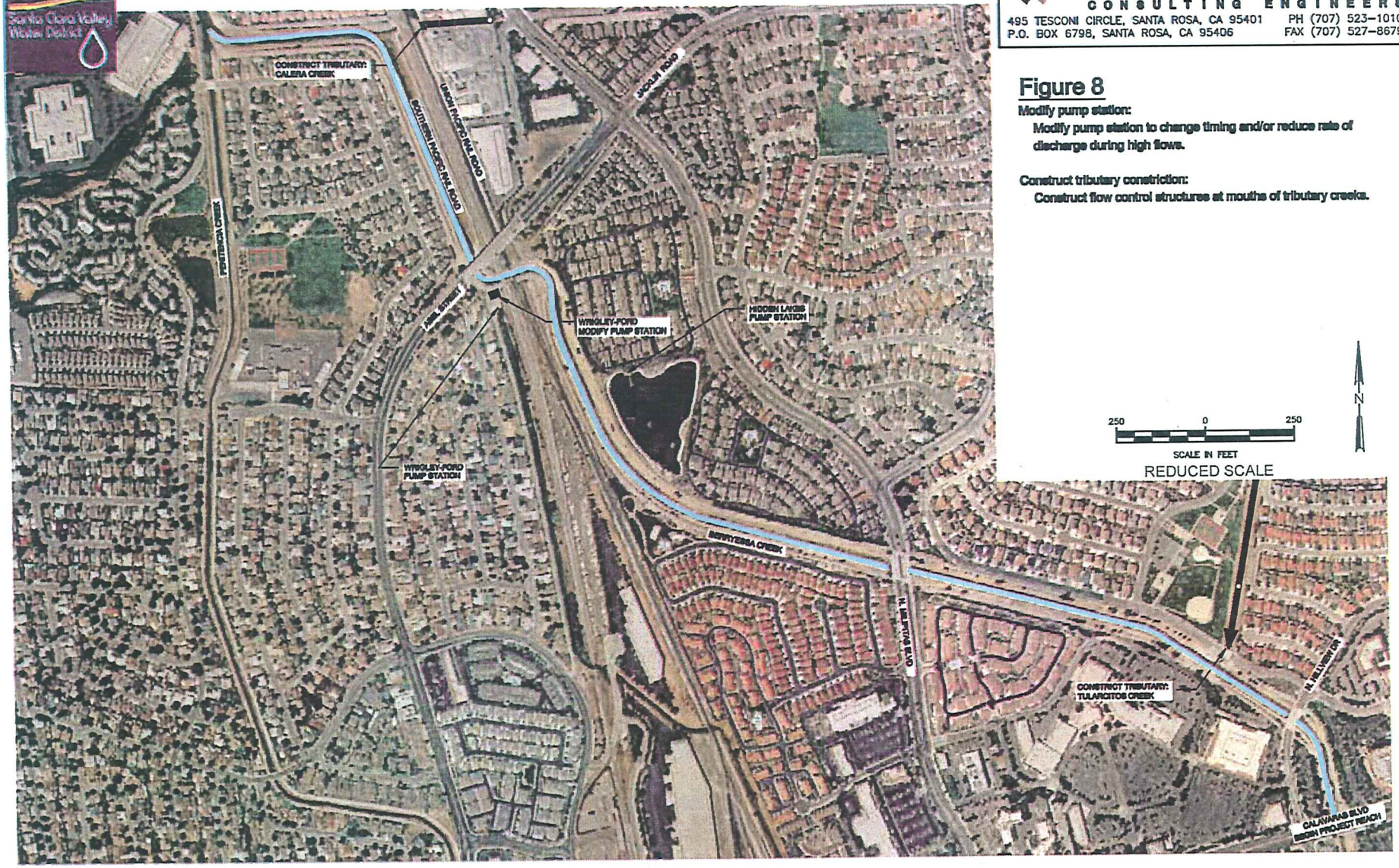
Figure 8

Modify pump station:

Modify pump station to change timing and/or reduce rate of discharge during high flows.

Construct tributary constriction:

Construct flow control structures at mouths of tributary creeks.



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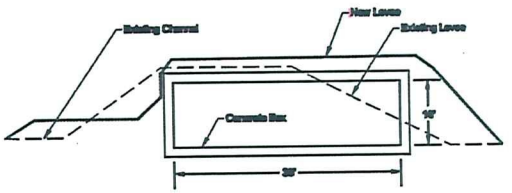


Figure 9

Upstream of railroad bridges:

Construct buried bypass conduit to reroute peak flow around constriction at railroad crossing.

Requires bored crossing under railroads.



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Corte Madera Creek WATERSHED
Santa Clara Valley Water District

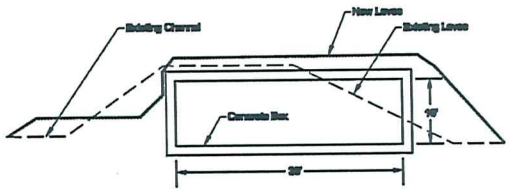


Figure 10

Downstream of railroad:

Construct buried bypass conduit to reroute peak flows from downstream of railroad crossing to confluence with penitanica creek.

N



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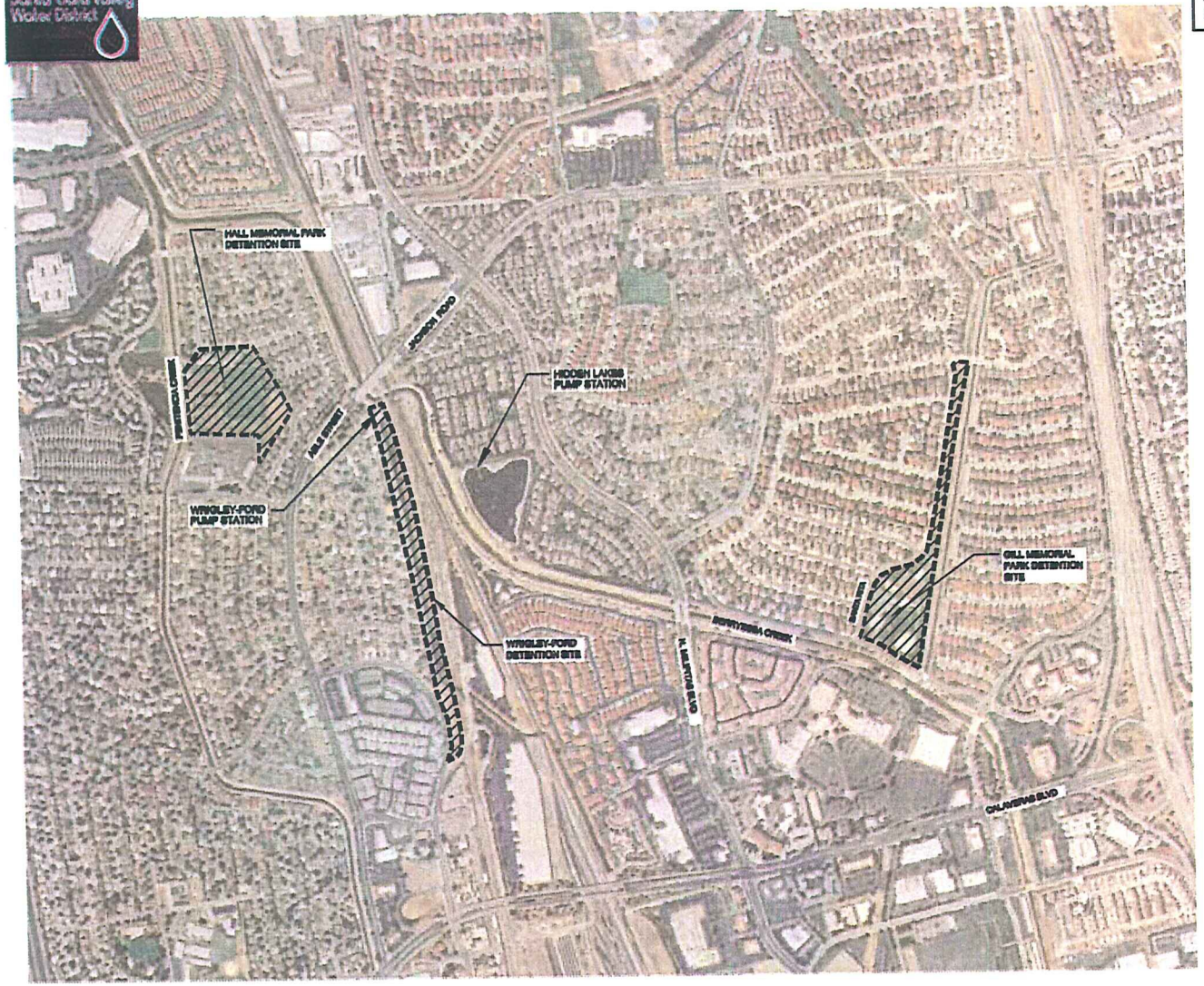


Figure 11

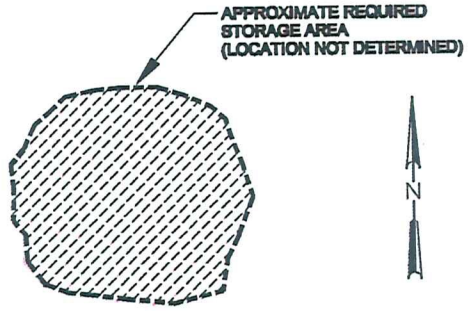
Detention Sites in Urban Watersheds

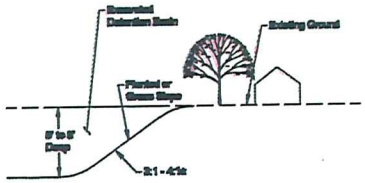
Wrigley-Ford:
Approximate percent of required storage: 14%

Gill Memorial Park:
Percent of required storage: 9%

Hall Memorial Park:
Approximate percent of required storage: 18%

Private Residences:
Approximate percent of required storage: 100%





PARTIAL SECTION
DETENTION BASIN

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Figure 12

Basins On Tributaries:

Construct detention basins at Tularcitos Creek and Calera Creek.

Approximate percent of required capacity: 30 %

N

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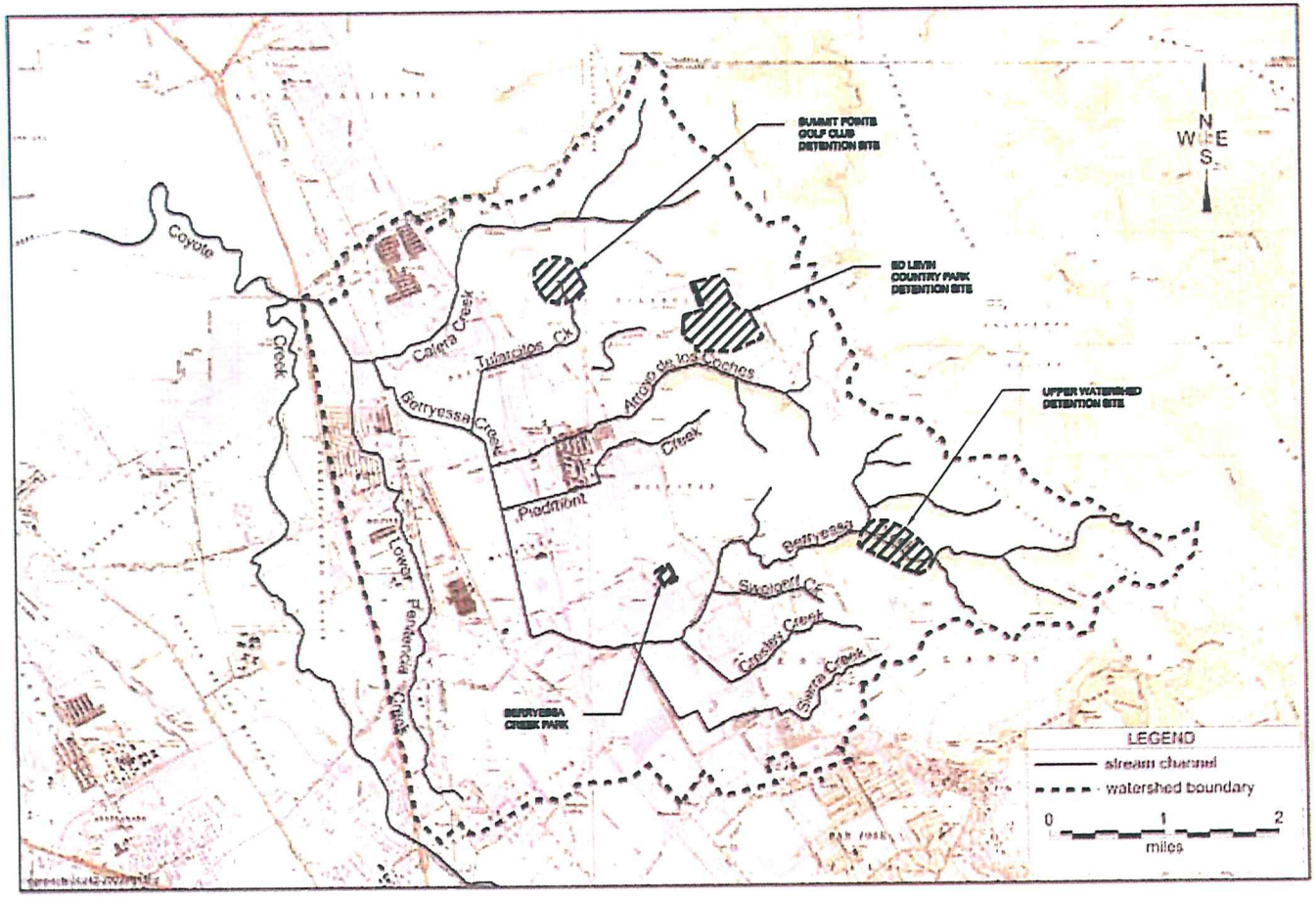


Figure 13

Berryessa Creek Park:
Construct Detention Basin located at the intersection of Messina and Isadora in the upper urban area of Berryessa Creek.

Approximate percent of required capacity: 15%

Summit Pointe Golf Club (Tularcitos Creek):
Construct Detention Basin located east of Highway 680 on Country Club Drive in Upper Tularcitos Creek Watershed.

Regrade site to capture full potential from Watershed.

Ed Levin County Park (Arroyo De Los Coches):
Construct Detention Basin located east of Highway 680 on Calaveras Road in upper Arroyo De Los Conces Watershed.

Regrade site to capture full potential from Watershed.

Upper Watershed (Berryessa Creek):
Construct Detention in upper Watershed area.

Difficult construction due to steep grades and erosive soils.

CONCEPT ALTERNATIVES MATRIX

NOVEMBER 7, 2003

Conceptual Alternatives	Existing Conditions	No Project	Managed Floodplain	Channel Modification Within Existing ROW			Channel Modification Within Existing ROW	
	(Figure 1)	(Figure 1)	Setback Levees (Figure 2)	Raise Levees (Figure 3)	Replace Levees with Floodwall (Figure 3)	Concrete Channel (Figure 4)	Replace Railroad Bridge (Figure 5)	Straighten Double 90 Reach (Figure 6)
Description of Conceptual Alternatives	Not Applicable	No improvements along Berryessa Creek downstream of Calaveras Blvd.	Increase width of channel and greatly reduce height of levees to re-create natural flood plain processes along Berryessa Creek. Flood plain would be planted with native riparian trees and vegetation. Widen bridges at road and railroad to not encroach on managed floodplain.	Raise levees in their current location with in the existing right-of-way and increase width of maintenance roads. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails.	Construct floodwalls at top of existing levees and increase widths of maintenance roads. Partially reconstruct levee slopes. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails.	Reconfigure the existing channel and line with concrete. Increase width of maintenance roads each side of channel. Provide access for and integrate with City trails	Two existing railroad bridges removed and reconstructed above the water surface elevation of a 100-year storm event.	Remove the existing double 90 degree bend in the channel and replace with a smoother "S" curve. Requires construction of new railroad crossing for relocated channel.
Flood Protection *Capability to provide 1 percent (100-year) level of protection*	Low. Less than 100-year level of protection.	Low. Level of flood protection would decrease due to development in watershed and upstream Corps project.	High. Flood plain would be cleared of structures and made wide enough to contain 100-year flows.	Limited. Less than 100-year level of protection, unless combined with other alternative(s), due to constriction at railroad crossing.	Limited. Less than 100-year level of protection, unless combined with other alternative(s), due to constriction at railroad crossing.	Limited. Less than 100-year level of protection, unless combined with other alternative(s), due to constriction at railroad crossing.	Limited. Less than 100-year level of protection, unless combined with raising the levees, installing a bypass channel, or widening the levees downstream; and, widening the levees upstream.	Limited. Less than 100-year level of protection, unless combined with raising the levees, installing a bypass channel, or widening the levees downstream; and, widening the levees upstream.
Maintenance Access *Capability to provide access for safe and efficient maintenance*	Low. Existing access roads do not provide adequate access.	Low. Existing condition would remain.	High. Flood plain not expected to require any channel maintenance program, other than removal of man-made trash and debris	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements.	High. Concrete channel would require less maintenance than existing conditions. Access improved by widening some access roads	Low. Existing condition would remain, except in immediate vicinity of RR crossing, where access would be improved.	Low. Existing condition would remain, except in immediate vicinity of S-bends, where access could be improved.
Erosion *Potential effects on erosion of channel and existing levees*	Negative. Levee stability threatened by slope erosion of expansive clays.	Negative. Erosion could increase due to development in watershed and upstream Corps project.	Positive. Velocities in flood plain would be very low, natural erosion/deposition process would occur.	Positive. New levee slope construction will reduce erosion.	Positive. New levee slope construction will reduce erosion.	Positive. Channel would contain most of high velocity flows and concrete lining won't erode.	Existing conditions would remain.	Existing conditions would remain.
Sedimentation *Potential effects on deposition or generation of sediment*	Sediments are deposited along project reach and removed in accordance with maintenance plan.	Less than significant.	Positive. While there may be an increase in sediment within channel, it would be deposited in a manner consistent with natural geomorphic processes.	Less than significant.	Less than significant.	Potentially negative. Concrete channel would have higher velocities which could convey more sediment downstream with unknown environmental and maintenance impacts.	Existing conditions would remain.	Existing conditions would remain.
Local Drainage *Potential effects on local surface and storm drainage systems*	No significant effects.	Less than significant change in local drainage	No significant changes to surface drainage. Wide, shallow channel would require reconfiguration of some storm drains.	Less than significant change in local drainage	Less than significant change in local drainage	Less than significant change in local drainage	Existing conditions would remain.	Existing conditions would remain.
Water Quality *Potential effects on water turbidity, temperature and/or pollution*	Degraded water quality	Existing condition would remain	Positive. Improvement in water quality due to improved creek environment.	Existing condition would remain.	Existing condition would remain.	Negative. Existing condition would deteriorate (temperature and dissolved oxygen) .	Existing condition would remain.	Existing condition would remain.
Riparian Vegetation *Potential effects on riparian vegetation in channel*	Degraded and discontinuous herbaceous riparian vegetation; current mtce practices continue	Existing condition would remain; current mtce practices continue	Positive. Significant increase in herbaceous and woody riparian vegetation.	Existing condition would remain.	Existing condition would remain.	Negative. Existing condition would significantly deteriorate; permanent loss of riparian herbaceous vegetation	Existing condition would remain.	Existing condition would remain.
Wetland *Potential effects on wetlands*	Wetland vegetation found across channel; mix of cattail, other native and non-native vegetation; current mtce practices continue	Existing condition would remain; current mtce practices continue	Unknown. Possible increase in wetland area; unknown response by wetland vegetation types.	Existing condition would remain.	Existing condition would remain.	Negative. Existing condition would significantly deteriorate; permanent loss of wetland vegetation	Existing condition would remain.	Existing condition would remain.
Wildlife Habitat *Potential effects on wildlife habitat*	Habitat quality is poor; no suitable habitat for other listed or special status species; current mtce practices continue	Existing condition would remain; current mtce practices continue	Probably positive. Possible increase in common wildlife habitat.	Existing condition would remain.	Existing condition would remain.	Negative. Existing condition would significantly deteriorate; permanent loss of wildlife habitat	Existing condition would remain.	Existing condition would remain.
Fisheries *Potential effects on fish habitat*	Habitat quality is poor; not a steelhead or salmonid creek; current mtce practices continue	Existing condition would remain; current mtce practices continue	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Negative. Existing condition would significantly deteriorate; permanent loss of fish habitat	Existing condition would remain.	Existing condition would remain.
Aesthetics *Visual quality as viewed from within project boundaries and from adjacent viewshed*	Low visual quality due to concrete, lack of landscaping, manmade look and lack of habitat complexity	Existing condition would remain; current mtce practices continue	Positive. Flood plain would create natural greenbelt in largely residential area.	Potentially negative. Taller levees, steeper slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Flood walls, steeper levee slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration.	Negative. Concrete lined channel would significantly deteriorate appearance along channel. Appearance from adjacent residences would remain essentially unchanged.	Probably neutral. Bridge would be more prominent (higher and longer), but viewshed is limited.	Potentially positive. Current concrete-lined channel could be replaced with vegetated earthen channel, improving visual quality along creek. Appearance from adjacent residences would remain essentially unchanged.
Recreation *Capability of providing public access to trails*	No planned or sanctioned recreational use; passive use occurs	Existing condition would remain	Positive. Flood plain would provide opportunities for creation of trails and parks in natural setting.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Marginally positive. Trails would be integrated with and access provided to maintenance roads, but negative aesthetics of channel would limit desire to use trails.	Existing condition would remain	Existing condition would remain
Real Estate Acquisition *Extent, difficulty, and cost of acquiring additional right-of-way*	Not applicable.	None	Very extensive, difficult and costly. Potenitally 100 residences and 4 commercial properties would need to be acquired to create floodplain of sufficient width.	None.	None.	None	None	Limited. Additional ROW would need to be acquired to accommodate longer curve. Land required is probably publicly-owned or undeveloped.
Construction Cost *Low (under $ 10 million) Medium ($10-20 million) High (over $20 million)*	Not applicable.	Not applicable.	High. Significantly over $20 million.	Medium.	Medium.	Medium.	Low.	Low.
Time to Complete Project *Potential for completing project prior to commencing upstream Corps project.*	Not applicable.	Not applicable.	Cannot be completed prior to Corps project. Real estate acquisition could take years. Removal/relocation of structures in flood plain extensive. Requires approvals and permits from railroads.	Can be completed prior to Corps project. No real estate acquisition required, conventional construction materials/methods.	Can be completed prior to Corps project. No real estate acquisition required, conventional construction materials/methods.	Can be completed prior to Corps project. No real estate acquisition required, conventional construction materials/methods.	Uncertain. Requires approvals and permits from railroads.	Uncertain. Requires approvals and permits from railroads.
Summary	Not applicable.	No project alternative does not meet project objectives.	Most likely not feasible due to real estate requirements, schedule, and cost.	A feasible alternative, if combined with alternative(s) that address constriction at RR crossing.	A feasible alternative, if combined with alternative(s) that address constriction at RR crossing.	Probably not a feasible alternative due to negative environmental and aesthetic impacts.	A feasible alternative, if combined with alternative(s) that provide flood protection upstream and downstream.	A feasible alternative, if combined with alternative(s) that provide flood protection upstream and downstream.

Conceptual Alternatives	Channel Modification Outside Existing ROW		Tributary Modification		Bypass Channel		Detention Basin in Urban	
	Widen Channel (Figure 7)	Raise Levees (Figure 7)	Modify Pump Stations (Figure 8)	Construct Tributary Constriction (Figure 8)	Upstream of Railroad (Figure 9)	Downstream of Railroad (Figure 10)	Wrigley-Ford (Figure 11)	Gill Memorial Park (Figure 11)
Description of Conceptual Alternatives	Widen channel as to contain 100-year flows without increasing height of levees from existing. Reconstruct levees with wider maintenance roads. Provide access for and integrate improvements with City trails. Bridges at railroad crossing would be widened. Bridges at road crossings may require widening.	Raise levees increase width of maintenance roads. Provide access for and integrate improvements with City trails.	Modify pump station to change timing and/or reduce rate of discharge during high flows.	Construct flow control structures at mouths of tributary creeks.	Construct buried bypass conduit to reroute peak flow around constriction at railroad crossing. Requires bored crossing under railroads.	Construct buried bypass conduit to reroute peak flows from downstream of railroad crossing to confluence with Penitencia Creek.	Construct detention basin located upstream of Wrigley-Ford pump station, west side of Berryessa Creek.	Construct detention basin located at the intersection of Paseo Refugio and Santa Rita, east of Berryessa Creek.
Flood Protection *Capability to provide 1 percent (100-year) level of protection*	High. 100-year level of protection provided.	Limited. Less than 100-year level of protection, unless combined with other alternative(s), due to constriction at railroad crossing.	Low. Probably unchanged from existing conditions.	Limited. May provide 100-year level of protection from flooding from Berryessa Creek, but would cause flooding along tributary creeks without additional tributary flood protection measures.	Limited. Less than 100-year level of protection, unless combined with a new bypass channel, widened channel, or raised levees downstream ofrailroad crossing.	Limited. Less than 100-year level of protection, unless combined with widened channnel or raise levees up stream or straightening the double 90 reach.	Low. Less than 100-year level of flood protection, unless combined with other upstream/downstream alternatives, due to limited available storage volume.	Low. Less than 100-year level of flood protection, unless combined with other upstream/downstream alternatives, due to limited available storage volume.
Maintenance Access *Capability to provide access for safe and efficient maintenance*	High. Access improved by widening maintenance roads at tops and inside toes of levees.	High. Access improved by widening maintenance roads at tops and inside toes of levees.	Low. Existing conditions would remain.	Low. Existing conditions would remain.	Low. Existing conditions would remain. Requires additional maintenance of difficult-to-access buried conduit.	Low. Existing conditions would remain. Requires additional maintenance of difficult-to-access buried conduit.	Low. Existing conditions would remain. Requires additional maintenance of detention basin.	Low. Existing conditions would remain. Requires additional maintenance of detention basin.
Erosion *Potential effects on erosion of channel and existing levees*	Positive. New levee slope construction will reduce erosion.	Positive. New levee slope construction will reduce erosion.	Existing conditions would remain.	Existing conditions would remain.	Limited positive. High velocity flows would bypass portions of levees and channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.	Limited positive. High velocity flows would bypass portions of levees and channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.
Sedimentation *Potential effects on deposition or generation of sediment*	Probably less than significant. Lower velocities in wider channel might cause additional sediment deposition.	Less than significant.	Existing conditions would remain.	Existing conditions would remain.	Unknown. Total sediment deposited along reach would probably remain unchanged, but bypass would alter sediment deposit locations.	Unknown. Bypass conduit would have higher velocities which could convey more sediment downstream with unknown environmental and maintenance impacts. Bypass would alter sediment deposit	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.
Local Drainage *Potential effects on local surface and storm drainage systems*	Less than significant change in local drainage	Less than significant change in local drainage	Probably negative. If rate of discharge decreased, local flooding may occur from detained surface and/or storm drainage flows.	Negative. Significant upstream drainage impacts along tributaries.	Less than significant	Less than significant	Potentially negative. Storm drainage systems will probably need to be modified to route flows to basin.	Potentially negative. Storm drainage systems will probably need to be modified to route flows to basin.
Water Quality *Potential effects on water turbidity, temperature and/or pollution*	Minor improvement in water quality due to increased creek environment; temp construction impacts	Existing condition would remain.	Probably less than significant. Could be some minor improvement in water quality due to increased holding time.	Probably less than significant. Could be some minor improvement in water quality due to increased holding time.	Probably less than significant due to infrequency of bypass flows.	Probably less than significant due to infrequency of bypass flows.	Potentially positive. Minor improvement in water quality due to increased holding time.	Potentially positive. Minor improvement in water quality due to increased holding time.
Riparian Vegetation *Potential effects on riparian vegetation in channel*	Probably positive. Potential for increase in herbaceous and woody riparian vegetation.	Existing condition would remain.	Probably less than significant. Could be some increase in herbaceous riparian vegetation in pump station tributaries	Probably less than significant. Could be some increase in herbaceous riparian vegetation in pump station tributaries	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Potentially positive. Possible increase in herbaceous riparian vegetation in basin.	Potentially positive. Possible increase in herbaceous riparian vegetation in basin.
Wetland *Potential effects on wetlands*	Unknown. Possible increase in wetland area; unknown response by wetland vegetation types.	Existing condition would remain.	Probably less than significant. Could be some increase in wetland vegetation in pump station tributaries.	Probably less than significant. Could be some increase in wetland vegetation in pump station tributaries.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Unknown. Possible increase in wetland area in basin but unknown response of wetland vegetation in channel.	Unknown. Possible increase in wetland area in basin but unknown response of wetland vegetation in channel.
Wildlife Habitat *Potential effects on wildlife habitat*	Probably positive. Possible increase in common wildlife habitat.	Existing condition would remain.	Probably less than significant. Could be some increase in habitat in pump station tributaries.	Probably less than significant. Could be some increase in habitat in pump station tributaries.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Potentially positive. Existing condition would remain in channel, but possible increase in common wildlife habitat in basin	Potentially positive. Existing condition would remain in channel, but possible increase in common wildlife habitat in basin
Fisheries *Potential effects on fish habitat*	Possible decrease in fishery habitat (shallower channel, increased temperature).	Existing condition would remain.	Existing condition would remain	Existing condition would remain	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Unknown. Existing conditions may remain or basin may alter flows in channel, dependingon storm drainage routing	Unknown. Existing conditions may remain or basin may alter flows in channel, dependingon storm drainage routing
Aesthetics *Visual quality as viewed from within project boundaries and from adjacent viewshed*	Potentially positive. More shallow levee slopes may provide more landscaping options on outside slopes of levees adjacent to residences. Opportunities for creek bed restoration.	Potentially negative. Taller and/or steeper levees could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration.	Existing condition would remain	Existing condition would remain	Potentially negative. Existing conditions would remain along most of the project reach. Some vertical walls and steep slopes probably required to accommodate buried conduit within existing ROW.	Potentially negative. Existing conditions would remain along most of the project reach. Some vertical walls and steep slopes probably required to accommodate buried conduit within existing ROW.	Potentially positive. Existing conditionwould remain in channel, but detention basins may provide additional open space.	Potentially negative. Existing condition would remain in channel, but park appearance may be degraded.
Recreation *Capability of providing public access to trails*	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Existing condition would remain	Existing condition would remain	Existing condition would remain	Existing condition would remain	Existing condition would remain along channel.	Potentially negative. Existing conditions would remain along channel, but detention basin may degrade park facilities and/or require seasonal closings.
Real Estate Acquisition *Extent, difficulty, and cost of acquiring additional right-of-way*	Significant. Would require acquisition of many residences and some commercial property. Potentially 52 residences, 2 commerical properties and easements from 2 railroad agencies will be required	Significant. Would require acquisition of many residences and some commercial property. Potentially 52 residences, 2 commerical properties and easements from 2 railroad agencies will be required	None.	None.	Limited. Some ROW acquisition may be required to accommodate buried conduit adjacent to existing levee.	Limited. Some ROW acquisition may be required to accommodate buried conduit adjacent to existing levee.	Limited. Requires easement from City of Milpitas, Union Pacific Group, and Southern Pacific Transportation Corporation, and a privately owned light industrial property.	Limited. Requires easement on public land.
Construction Cost *Low (under $ 10 million) Medium ($10-20 million) High (over $20 million)*	High.	High.	Low.	Low.	Medium.	Medium.	Low.	Low.
Time to Complete Project *Potential for completing project prior to commencing upstream Corps project.*	Probably cannot be completed prior to Corps project. Requires real estate acquisition. Requiresapproval and permits from railroad and City for new crossings.	Probably cannot be completed prior to Corps project. Requires real estate acquisition. Requiresapproval and permits from railroad and City for new crossings.	Can be completed prior to Corps project.	Can be completed prior to Corps project.	Can probably be completed prior to Corps project. Requires some real estate acquisition. Requires approvals and permits from railroads.	Can probably be completed prior to Corps project. Requires some real estate acquisition.	Can probably be completed prior to Corps project. Requires some real estate acquisition.	Can be completed prior to Corps project.
Summary	Probably not feasible due real estate requirements, cost, and schedule.	A questionable alternative, due to real estate requirements and schedule.	Probably not a feasible alternative because it doesn't significantly reduce flood risk.	Probably not a feasible alternative because of flood risk created along tributary creeks.	A feasible alternative, if combined with alternative(s) that provide flood protection upstream and downstream.	A feasible alternative, if combined with alternative(s) that provide flood protection upstream and downstream.	Not a feasible alternative, due to limited available storage volume.	Not a feasible alternative, due to limited available storage volume.

Conceptual Alternatives	**atershed** (cont'd next page)		**Detention Basin in Urban Watershed** (cont'd)		**Detention Basin in Upper Watershed**		
	Hall Memorial Park (Figure 11)	Berryessa Creek Park (Figure 13)	Private Residences (Figure 11)	Basin on Tributary Creeks (Figure 12)	Summitpointe Golf Club (Tularcitos Creek) (Figure 13)	Ed Levin County Park (Arroyo De Los Coches Creek) (Figure 13)	Upper Watershed (Berryessa Creek) (Figure 13)
Description of Conceptual Alternatives	Construct detention basin located downstream of the double-90 degree bends at the railroad crossing.	Construct detention basin located at the intersection of Messina and Isadora in the upper urban area of Berryessa Creek.	Construct detention basin located between Able Street and Wrigley-Ford channel.	Construct detention basin located at both Tularcitos Creek and Calara Creek	Construct detention basin located east of Highway 680 on Country Club Drive in the upper Tularcitos Creek watershed. Reconstruct golf course in detention basin.	Construct detention basin located east of Highway 680 on Calaveras Road in the upper Arroyo de los Conches watershed.	Construct detention in upper Berryessa Creek watershed area. .
Flood Protection *Capability to provide 1 percent (100-year) level of protection*	Low. Less than 100-year level of flood protection, unless combined with other upstream/downstream alternatives, due to limited available storage volume.	Low. Less than 100-year level of flood protection, unless combined with other upstream/downstream alternatives, due to limited available storage volume.	High. Sufficient storage volume to provide 100-year level of flood protection.	Low. Less than 100-year level of flood protection, unless combined with other upstream/downstream alternatives, due to limited available storage volume.	Limited. Less than 100-year level of flood protection, unless combined with other upstream/downstream alternatives, due to limited available storage volume.	Limited. Less than 100-year level of flood protection, unless combined with other upstream/downstream alternatives, due to limited available storage volume.	Limited to High. Could provide 100-year level of protection if sufficient storage volume available. Otherwise, would need to be combined with other alternatives.
Maintenance Access *Capability to provide access for safe and efficient maintenance*	Low. Existing conditions would remain. Requires additional maintenance of detention basin.	Low. Existing conditions would remain. Requires additional maintenance of detention basin.	Low. Existing conditions would remain. Requires additional maintenance of detention basin.	Low. Existing conditions would remain. Requires additional maintenance of detention basin.	Low. Existing conditions would remain. Requires additional maintenance of detention basin.	Low. Existing conditions would remain. Requires additional maintenance of detention basin.	Low. Existing conditions would remain. Requires additional maintenance of detention basin.
Erosion *Potential effects on erosion of channel and existing levees*	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Limited positive. Detention could reduce flow velocities in channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.
Sedimentation *Potential effects on deposition or generation of sediment*	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Less than significant. Existing conditions would remain essentially unchanged.	Potentially positive. Detention could reduce sediment load transported to channel.
Local Drainage *Potential effects on local surface and storm drainage systems*	Potentially negative. Storm drainage systems will probably need to be modified to route flows to basin.	Potentially negative. Storm drainage systems will probably need to be modified to route flows to basin.	Potentially negative. Storm drainage systems will probably need to be modified to route flows to basin.	Potentially negative. Storm drainage systems will probably need to be modified to route flows to basin.	Potentially negative. Surface drainage will probably need to be modified to route flows to basin.	Potentially negative. Surface drainage will probably need to be modified to route flows to basin.	Potentially negative. Surface drainage will probably need to be modified to route flows to basin.
Water Quality *Potential effects on water turbidity, temperature and/or pollution*	Potentially positive. Minor improvement in water quality due to increased holding time.	Potentially positive. Minor improvement in water quality due to increased holding time.	Potentially positive. Minor improvement in water quality due to increased holding time.	Potentially positive. Minor improvement in water quality due to increased holding time.	Potentially positive. Minor improvement in water quality due to increased holding time.	Potentially positive. Minor improvement in water quality due to increased holding time.	Potentially positive. Minor improvement in water quality due to increased holding time.
Riparian Vegetation *Potential effects on riparian vegetation in channel*	Potentially positive. Possible increase in herbaceous riparian vegetation in basin.	Potentially positive. Possible increase in herbaceous riparian vegetation in basin.	Potentially positive. Possible increase in herbaceous riparian vegetation in basin.	Potentially positive. Possible increase in herbaceous riparian vegetation in basin.	Potentially positive. Possible increase in herbaceous riparian vegetation in basin.	Potentially positive. Possible increase in herbaceous riparian vegetation in basin.	Potentially positive. Possible increase in herbaceous riparian vegetation in basin.
Wetland *Potential effects on wetlands*	Unknown. Possible increase in wetland area in basin but unknown response of wetland vegetation in channel.	Unknown. Possible increase in wetland area in basin but unknown response of wetland vegetation in channel.	Unknown. Possible increase in wetland area in basin but unknown response of wetland vegetation in channel.	Unknown. Possible increase in wetland area in basin but unknown response of wetland vegetation in channel.	Unknown. Possible increase in wetland area in basin but unknown response of wetland vegetation in channel.	Unknown. Possible increase in wetland area in basin but unknown response of wetland vegetation in channel.	Unknown. Possible increase in wetland area in basin but unknown response of wetland vegetation in channel.
Wildlife Habitat *Potential effects on wildlife habitat*	Potentially positive. Existing condition would remain in channel, but possible increase in common wildlife habitat in basin	Potentially positive. Existing condition would remain in channel, but possible increase in common wildlife habitat in basin	Potentially positive. Existing condition would remain in channel, but possible increase in common wildlife habitat in basin	Potentially positive. Existing condition would remain in channel, but possible increase in common wildlife habitat in basin	Potentially positive. Existing condition would remain in channel, but possible increase in common wildlife habitat in basin	Potentially positive. Existing condition would remain in channel, but possible increase in common wildlife habitat in basin	Potentially positive. Existing condition would remain in channel, but possible increase in common wildlife habitat in basin
Fisheries *Potential effects on fish habitat*	Unknown. Existing conditions may remain or basin may alter flows in channel, depending on storm drainage routing	Unknown. Existing conditions may remain or basin may alter flows in channel, depending on storm drainage routing	Unknown. Existing conditions may remain or basin may alter flows in channel, depending on storm drainage routing	Unknown. Existing conditions may remain or basin may alter flows in channel, depending on storm drainage routing	Unknown. Existing conditions may remain or basin may alter flows in channel, depending on storm drainage routing	Unknown. Existing conditions may remain or basin may alter flows in channel, depending on storm drainage routing	Unknown. Existing conditions may remain or basin may alter flows in channel, depending on storm drainage routing
Aesthetics *Visual quality as viewed from within project boundaries and from adjacent viewshed*	Potentially negative. Existing condition would remain in channel, but park appearance may be degraded.	Potentially negative. Existing condition would remain in channel, but park appearance may be degraded.	Potentially positive. Existing condition would remain in channel, but detention basins may provide additional open space.	Potentially positive. Existing condition would remain in channel, but detention basins may provide additional open space.	Potentially negative. Existing condition would remain in channel, but golf course appearance may be degraded.	Potentially negative. Existing condition would remain in channel, but park appearance may be degraded.	Potentially positive. Existing condition would remain in channel, but detention basins may provide additional open space.
Recreation *Capability of providing public access to trails*	Potentially negative. Existing conditions would remain along channel, but detention basin may degrade park facilities and/or require seasonal closings.	Potentially negative. Existing conditions would remain along channel, but detention basin may degrade park facilities and/or require seasonal closings.	Potentially positive. Open space provided by detention basin could provide recreational opportunities.	Existing condition would remain along channel.	Potentially negative. Existing conditions would remain along channel, but detention basin may degrade golf course and/or require seasonal closings.	Potentially negative. Existing conditions would remain along channel, but detention basin may degrade park facilities and/or require seasonal closings.	Potentially positive. Open space provided by detention basin could provide recreational opportunities.
Real Estate Acquisition *Extent, difficulty, and cost of acquiring additional right-of-way*	Limited. Requires easement on public land.	Limited. Requires easement on public land.	Extensive, difficult, and extremely costly acquisition of potentially 250 private residences required.	Little or none.	Extensive acquisition of easement on private land.	Limited. Requires easement on public land.	Extensive acquisition of private land.
Construction Cost *Low (under $ 10 million) Medium ($10-20 million) High (over $20 million)*	Low.	Low.	High.	Low.	Medium.	Medium.	Medium.
Time to Complete Project *Potential for completing project prior to commencing upstream Corps project.*	Can be completed prior to Corps project.	Can be completed prior to Corps project.	Cannot be completed prior to Corps project. Extensive real estate acquisition required.	Can be completed prior to Corps project.	Uncertain. Dependent on obtaining easement on private land.	Can be completed prior to Corps project.	Uncertain. Dependent on acquisition of real estate.
Summary	Not a feasible alternative, due to limited available storage volume.	Not a feasible alternative, due to limited available storage volume.	Not a feasible alternative, due to high cost and time required for real estate acquisition.	Not a feasible alternative, due to limited available storage volume.	Not a feasible alternative, due to limited available storage volume and cost/time required to obtain easement on private land.	Not a feasible alternative, due to limited available storage volume.	Probably not a feasible alternative due to time and uncertainties in acquiring real estate for sufficient storage volume.

FEASIBLE ALTERNATIVES MATRIX

Conceptual Alternatives	Raise Levees within the ROW					Replace Levees with Floodwall					Raise Levees Outside ROW					Bypass Downstream of Railroad		
	Only (Figure 1)	With Railroad Bridge Replacement (Figure 2)	With Straighten Double 90's (Figure 3)	With Bypass Upstream of Railroad (Figure 4)	With Bypass Downstream of Railroad (Figure 5)	Only (Figure 1)	With Railroad Bridge Replacement (Figure 2)	With Straighten Double 90's (Figure 3)	With Bypass Upstream of Railroad (Figure 4)	With Bypass Downstream of Railroad (Figure 5)	Only (Figure 10)	With Replace Railroad Bridge (Figure 6)	With Straighten Double 90 Reach (Figure 8)	With Bypass Upstream of Railroad (Figure 11)	With Bypass Downstream of Railroad (Figure 12)	With Replace Railroad Bridge (Figure 7)	With Straighten Double 90 Reach (Figure 9)	With Bypass Channel Upstream of Railroad (Figure 13)
Description of Conceptual Alternatives	Raise levees in their current location with in the existing right-of-way and increase width of maintenance roads. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails.	Raise levees in their current location with in the existing right-of-way and increase width of maintenance roads. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails. Two existing railroad bridges removed and reconstructed above the water surface elevation of a 100-year storm event.	Raise levees in their current location with in the existing right-of-way and increase width of maintenance roads. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails Remove the existing double 90 degree bend in the channel and replace with a smoother "S" curve. Requires construction of new railroad crossing for relocated channel.	Raise levees in their current location with in the existing right-of-way and increase width of maintenance roads. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails. Construct buried bypass conduit to reroute peak flow around constriction at railroad crossing. Requires bored crossing under railroads.	Raise levees in their current location with in the existing right-of-way and increase width of maintenance roads. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails. Construct buried bypass conduit to reroute peak flows from downstream of railroad crossing to confluence with Penitencia Creek.	Construct floodwalls at top of existing levees and increase widths of maintenance roads. Partially reconstruct levee slopes. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails.	Construct floodwalls at top of existing levees and increase widths of maintenance roads. Partially reconstruct levee slopes. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails. Construct floodwalls at top of existing levees and increase widths of maintenance roads. Partially reconstruct levee slopes. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails. Remove the existing double 90 degree bend in the channel and replace with a smoother "S" curve. Requires construction of new railroad crossing for relocated channel.	Construct floodwalls at top of existing levees and increase widths of maintenance roads. Partially reconstruct levee slopes. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails. Construct buried bypass conduit to reroute peak flow around constriction at railroad crossing. Requires bored crossing under railroads.	Construct floodwalls at top of existing levees and increase widths of maintenance roads. Partially reconstruct levee slopes. Steep levee slopes and retaining walls required in some locations. Provide access for and integrate improvements with City trails. Construct buried bypass conduit to reroute peak flows from downstream of railroad crossing to confluence with Penitencia Creek.	Raise levees increase width of maintenance roads. Provide access for and integrate improvements with City trails.	Two existing railroad bridges removed and reconstructed above the water surface elevation of a 100-year storm event. Raise levees increase width of maintenance roads. Provide access for and integrate improvements with City trails.	Remove the existing double 90 degree bend in the channel and replace with a smoother "S" curve. Requires construction of new railroad crossing for relocated channel. Raise levees increase width of maintenance roads. Provide access for and integrate improvements with City trails. This option may require raising the levees or installing a floodwall upstream of the railroad bridge.	Raise levees increase width of maintenance roads. Provide access for and integrate improvements with City trails. Construct buried bypass conduit to reroute peak flow around constriction at railroad crossing. Requires bored crossing under railroads.	Raise levees increase width of maintenance roads. Provide access for and integrate improvements with City trails. Construct buried bypass conduit to reroute peak flows from downstream of railroad crossing to confluence with Penitencia Creek.	Two existing railroad bridges removed and reconstructed above the water surface elevation of a 100-year storm event. Construct buried bypass conduit to reroute peak flows from downstream of railroad crossing to confluence with Penitencia Creek. This option may require raising the levees or installing a flood wall upstream of the railroad bridge.	Remove the existing double 90 degree bend in the channel and replace with a smoother "S" curve. Construct buried bypass conduit to reroute peak flows from downstream of railroad crossing to confluence with Penitencia Creek. This option may require raising the levees or installing a floodwall upstream of the railroad bridge.	Construct buried bypass conduit to reroute peak flow around constriction at railroad crossing. Requires bored crossing under railroads. Construct buried bypass conduit to reroute peak flows from downstream of railroad crossing to confluence with Penitencia Creek.
Flood Protection *Capability to provide 1 percent (100-year) level of protection*	Provides 100-year level of protection. Requires modifications at railroad bridges to allow pressure flow.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection. Requires modifications at railroad bridges to allow pressure flow.	Provides 100-year level of protection. Requires modifications at railroad bridges to allow pressure flow.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection. Requires modifications at railroad bridges to allow pressure flow.	Provides 100-year level of protection. Requires modifications at railroad bridges to allow pressure flow.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection. Requires modifications at railroad bridges to allow pressure flow.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection.
Maintenance Access *Capability to provide access for safe and efficient maintenance*	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements. Requires additional maintenance of difficult-to-access buried conduit.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements. Requires additional maintenance of difficult-to-access buried conduit.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements. Requires additional maintenance of difficult-to-access buried conduit.	Moderate. Access improved by widening some maintenance roads. Right of way limits extent of improvements. Requires additional maintenance of difficult-to-access buried conduit.	High. Access improved by widening maintenance roads at tops and inside toes of levees.	High. Access improved by widening maintenance roads at tops and inside toes of levees.	High. Access improved by widening maintenance roads at tops and inside toes of levees and in immediate vicinity of S-bends.	High. Access improved by widening maintenance roads at tops and inside toes of levees. Requires additional maintenance of difficult-to-access buried conduit.	Moderate. Access improved by widening maintenance roads at tops and inside toes of levees. Requires additional maintenance of difficult-to-access buried conduit.	Low. Existing condition would remain. Requires additional maintenance of difficult-to-access buried conduit.	Low. Requires additional maintenance of difficult-to-access buried conduit and improvement of access to the vicinity of S-bends.	Low. Existing conditions would remain. Requires additional maintenance of difficult-to-access buried conduit.
Erosion *Potential effects on erosion of channel and existing levees*	Positive. New levee slope construction will reduce erosion.	Positive. New levee slope construction will reduce erosion.	Positive. New levee slope construction will reduce erosion.	Limited Positive. High velocity flows would bypass portions of levees and channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.	Limited Positive. High velocity flows would bypass portions of levees and channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.	Positive. New levee slope construction will reduce erosion.	Positive. New levee slope construction will reduce erosion.	Positive. New levee slope construction will reduce erosion.	Positive. High velocity flows would bypass portions of levees and channel, reducing erosion.	Positive. High velocity flows would bypass portions of levees and channel, reducing erosion.	Positive. New levee slope construction will reduce erosion.	Positive. New levee slope construction will reduce erosion.	Positive. New levee slope construction will reduce erosion.	Positive. High velocity flows would bypass portions of levees and channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.	Positive. High velocity flows would bypass portions of levees and channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.	Positive. High velocity flows would bypass portions of levees and channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.	Limited Positive. High velocity flows would bypass portions of levees and channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.	Limited Positive. High velocity flows would bypass portions of levees and channel, reducing erosion. Existing levee slope instability due to expansive soils would remain.
Sedimentation *Potential effects on deposition or generation of sediment*	Less than significant.	Less than significant.	Less than significant.	Unknown. Total sediment deposited along reach would probably remain unchanged, but bypass would alter sediment deposit locations.	Unknown. Bypass conduit would have higher velocities which could convey more sediment downstream with unknown environmental and maintenance impacts. Bypass would alter sediment deposit locations	Less than significant.	Less than significant.	Less than significant.	Unknown. Total sediment deposited along reach would probably remain unchanged, but bypass would alter sediment deposit locations.	Unknown. Bypass conduit would have higher velocities which could convey more sediment downstream with unknown environmental and maintenance impacts. Bypass would alter sediment deposit locations	Less than significant.	Less than significant.	Less than significant.	Unknown. Total sediment deposited along reach would probably remain unchanged, but bypass would alter sediment deposit locations.	Unknown. Bypass conduit would have higher velocities which could convey more sediment downstream with unknown environmental and maintenance impacts. Bypass would alter sediment	Unknown. Bypass conduit would have higher velocities which could convey more sediment downstream with unknown environmental and maintenance impacts. Bypass would alter sediment deposit locations	Unknown. Bypass conduit would have higher velocities which could convey more sediment downstream with unknown environmental and maintenance impacts. Bypass would alter sediment	Unknown. Bypass conduit would have higher velocities which could convey more sediment downstream with unknown environmental and maintenance impacts. Bypass would alter sediment
Local Drainage *Potential effects on local surface and storm drainage systems*	Less than significant change in local drainage	Less than significant	Less than significant	Less than significant	Less than significant	Less than significant change in local drainage	Less than significant.	Less than significant.	Less than significant.	Less than significant.	Less than significant change in local drainage	Less than significant.	Less than significant	Less than significant in local drainage	Less than significant in local drainage	Less than significant.	Less than significant	Less than significant in local drainage
Water Quality *Potential effects on water turbidity, temperature and/or pollution*	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Probably less than significant due to infrequency of bypass flows.	Probably less than significant due to infrequency of bypass flows.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Probably less than significant due to infrequency of bypass flows.	Probably less than significant due to infrequency of bypass flows.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Probably less than significant due to infrequency of bypass flows.	Probably less than significant due to infrequency of bypass flows.	Less than significant.	Probably less than significant due to infrequency of bypass flows.	Probably less than significant due to infrequency of bypass flows.
Riparian Vegetation *Potential effects on riparian vegetation in channel*	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.
Wetland *Potential effects on wetlands*	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.
Wildlife Habitat *Potential effects on wildlife habitat*	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.
Fisheries *Potential effects on fish habitat*	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.	Existing condition would remain. Bypass flows would occur very infrequently.
Aesthetics *Visual quality as viewed from within project boundaries and from adjacent viewshed*	Potentially negative. Taller levees, steeper slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Bridge would be more prominent (higher and longer), taller levees, steeper slopes, and retaining walls could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Taller levees, steeper slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Taller levees, steeper slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Vertical walls and steep slopes likely required to accommodate buried conduit within existing ROW. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Taller levees, steeper slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Vertical walls and steep slopes likely required to accommodate buried conduit within existing ROW. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Flood walls, steeper levee slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Bridge would be more prominent (higher and longer), taller levees, steeper slopes, and retaining walls could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Flood walls, steeper levee slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Flood walls, steeper levee slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Some vertical walls and steeper slopes likely required to accommodate buried conduit within existing ROW. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Flood walls, steeper levee slopes and retaining walls could deteriorate appearance from adjacent residences and along channel. Some vertical walls and steeper slopes likely required to accommodate buried conduit within existing ROW. Some potential for mitigation by landscaping and creek bed restoration.	Unknown. Taller levees may have negative impact, but additional ROW may provide opportunities to improve quality. Taller and/or steeper levees could deteriorate appearance from adjacent residences and along channel.	Unknown. Taller levees may have negative impact, but additional ROW may provide opportunities to improve quality.	Unknown. Taller levees may have negative impact, but additional ROW may provide opportunities to improve quality.	Potentially negative. Taller and/or steeper levees could deteriorate appearance from adjacent residences and along channel. They are also required to accommodate buried conduit within the ROW. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Taller and/or steeper levees could deteriorate appearance from adjacent residences and along channel. They are also required to accommodate buried conduit the existing ROW. Some potential for mitigation by landscaping and creek bed restoration.	Potentially negative. Bridge would be more prominent (higher and longer), but viewshed is limited. Some vertical walls and steep slopes probably required to accommodate buried conduit within existing ROW.	Potentially negative. Existing conditions would remain along most of the project reach. Some vertical walls and steep slopes probably required to accommodate buried conduit within existing ROW.	Potentially negative. Existing conditions would remain along most of the project reach. Some vertical walls and steep slopes probably required to accommodate buried conduit within existing ROW.
Recreation *Capability of providing public access to trails*	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Existing condition would remain.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive. Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Positive Trails would be integrated with and access provided to raised levees and/or maintenance roads.	Potentially positive. Trails would be accomotdated on top of bypass.	Potentially positive. Trails would be accomotdated on top of bypass.	Existing condition would remain
Real Estate Acquisition *Extent, difficulty, and cost of acquiring additional right-of-way*	None.	None.	Limited. Additional ROW would need to be acquired to accommodate longer curve. Land required is probably publicly-owned or undeveloped.	Limited. Some ROW acquisition may be required to accommodate buried conduit adjacent to existing levee.	Limited. Some ROW acquisition may be required to accommodate buried conduit adjacent to existing levee.	None.	None.	Limited. Additional ROW would need to be acquired to accommodate longer curve. Land required is probably publicly-owned or undeveloped.	Limited. Some ROW acquisition may be required to accommodate buried conduit adjacent to existing levee.	Limited. Some ROW acquisition may be required to accommodate buried conduit adjacent to existing levee.	Significant. Would require acquisition of many residences and some commercial property. Potentially 52 residences, 2 commercial properties and easements from 2 railroad agencies will be required.	Significant. Would require acquisition of many residences and some commercial property. Potentially 52 residences, 2 commercial properties and easements from 2 railroad agencies will be required.	Significant. Would require acquisition of many residences and some commercial property. Potentially 52 residences, 2 commercial properties and easements from 2 railroad agencies will be required.	Significant. Would require acquisition of many residences and some commercial property. Potentially 52 residences, 2 commercial properties and easements from 2 railroad agencies will be required. Additional ROW required for bypass channel.	Significant. Would require acquisition of many residences and some commercial property. Potentially 52 residences, 2 commercial properties and easements from 2 railroad agencies will be required. Additional ROW required for bypass channel.	Limited. Some ROW acquisition may be required to accommodate buried conduit adjacent to existing levee.	Limited. Additional ROW would need to be acquired to accommodate longer curve and also buried conduit adjacent to existing levee. Land required is probably publicly-owned or undeveloped.	Limited. Some ROW acquisition may be required to accommodate buried conduit adjacent to existing levee.
Construction Cost *Low (under $ 10 million) Medium ($10-20 million) High (over $20 million)*	Medium.	Medium.	Medium.	High.	High.	Medium.	Medium.	Medium.	High.	High.	High.	High.	High.	High.	High.	Medium.	Medium.	High.
Time to Complete Project *Potential for completing project prior to commencing upstream Corps project.*	Can be completed prior to Corps project. No real estate acquisition required, conventional construction materials/methods.	Can be completed prior to Corps project. No real estate acquisition required, conventional construction materials/methods. RR requires approvals and permits.	Can be completed prior to Corps project. No real estate acquisition required, conventional construction materials/methods. RR requires approvals and permits.	Can probably be completed prior to Corps project. Requires some real estate acquisition. Requires approvals and permits from railroads.	Can probably be completed prior to Corps project. Requires some real estate acquisition. Requires approvals and permits from railroads.	Can be completed prior to Corps project. No real estate acquisition required, conventional construction materials/methods.	Can be completed prior to Corps project. No real estate acquisition required, conventional construction materials/methods. Requires approvals and permits from railroads.	Can be completed prior to Corps project. Limited real estate acquisition required, conventional construction materials/methods. Requires approvals and permits from railroads.	Can probably be completed prior to Corps project. Requires some real estate acquisition. Requires approvals and permits from railroads.	Can probably be completed prior to Corps project. Requires some real estate acquisition.	Probably cannot be completed prior to Corps project. Requires real estate acquisition. Requires approval and permits from railroad and City for new crossings.	Probably cannot be completed prior to Corps project. Requires real estate acquisition. Requires approval and permits from railroad and City for new crossings.	Probably cannot be completed prior to Corps project. Requires real estate acquisition. Requires approval and permits from railroad and City for new crossings.	Probably cannot be completed prior to Corps project. Requires real estate acquisition. Requires approval and permits from railroad and City for new crossings.	Probably cannot be completed prior to Corps project. Requires real estate acquisition. Requires approval and permits from railroad and City for new crossings.	Can probably be completed prior to Corps project. Requires some real estate acquisition and approvals and permits from railroads.	Can probably be completed prior to Corps project. Requires some real estate acquisition, approvals and permits from railroads.	Can probably be completed prior to Corps project. Requires some real estate acquisition. Requires approvals and permits from railroads.
Summary	A feasible alternative. Requires modifications at railroad bridges to allow pressure flow.	A feasible alternative that addresses constriction at RR crossing and provides flood protection upstream and downstream.	A feasible alternative that addresses constriction at RR crossing and provides flood protection upstream and downstream.	A feasible alternative that addresses constriction at RR crossing and provides flood protection upstream and downstream.	A feasible alternative. Requires modifications at railroad bridges to allow pressure flow.	A feasible alternative. Requires modifications at railroad bridges to allow pressure flow.	A feasible alternative that addresses constriction at RR crossing and provides flood protection upstream and downstream.	A feasible alternative that addresses constriction at RR crossing and provides flood protection upstream and downstream.	A feasible alternative that addresses constriction at RR crossing and provides flood protection upstream and downstream.	A feasible alternative. Requires modifications at railroad bridges to allow pressure flow.	A questionable alternative, due to real estate requirements and schedule. Requires modifications at railroad bridges to allow pressure flow.	A questionable alternative, due to real estate requirements and schedule.	A questionable alternative, due to real estate requirements and schedule	A questionable alternative, due to real estate requirements and schedule.	A questionable alternative, due to real estate requirements and schedule. Requires modifications at railroad bridges to allow pressure flow.	A feasible alternative that addresses constriction at RR crossing and provides flood protection upstream and downstream. Requires approvals and permits from railroads.	A feasible alternative that addresses constriction at RR crossing and provides flood protection upstream and downstream. Requires approvals and permits from railroads.	A feasible alternative that addresses constriction at RR crossing and provides flood protection upstream and downstream. Requires approvals and permits from railroads.

ALTERNATIVES FIGURES



FIGURE-1

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401
P.O. BOX 8795, SANTA ROSA, CA 95406
PH (707) 523-1010
FAX (707) 527-8679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District

ACCEPTED BY DISTRICT

DATE

LEVEES WITHIN ROW ALTERNATIVE
ALTERNATIVE 1&2
BERRYESSA CREEK LEVEES PROJECT

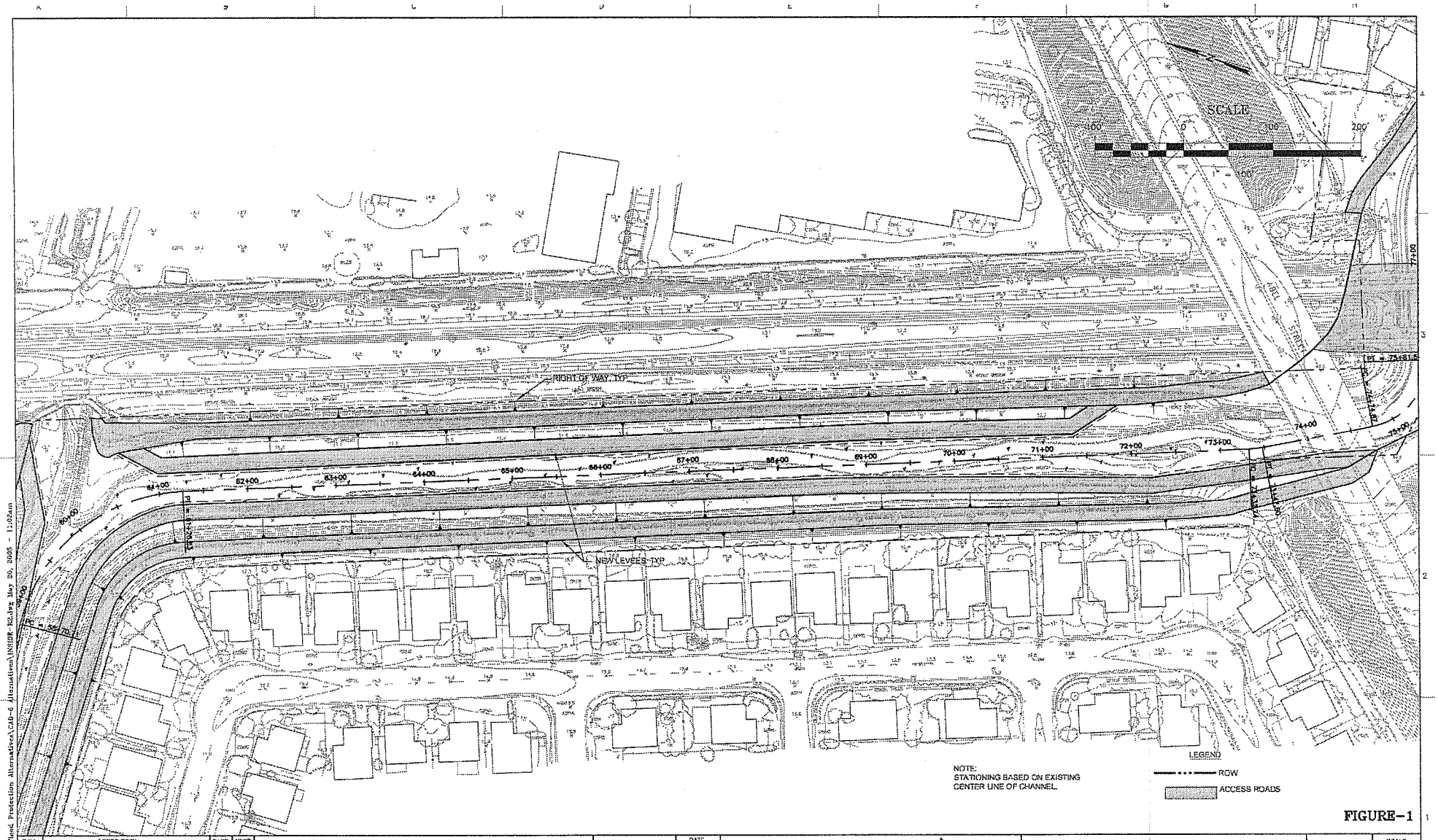
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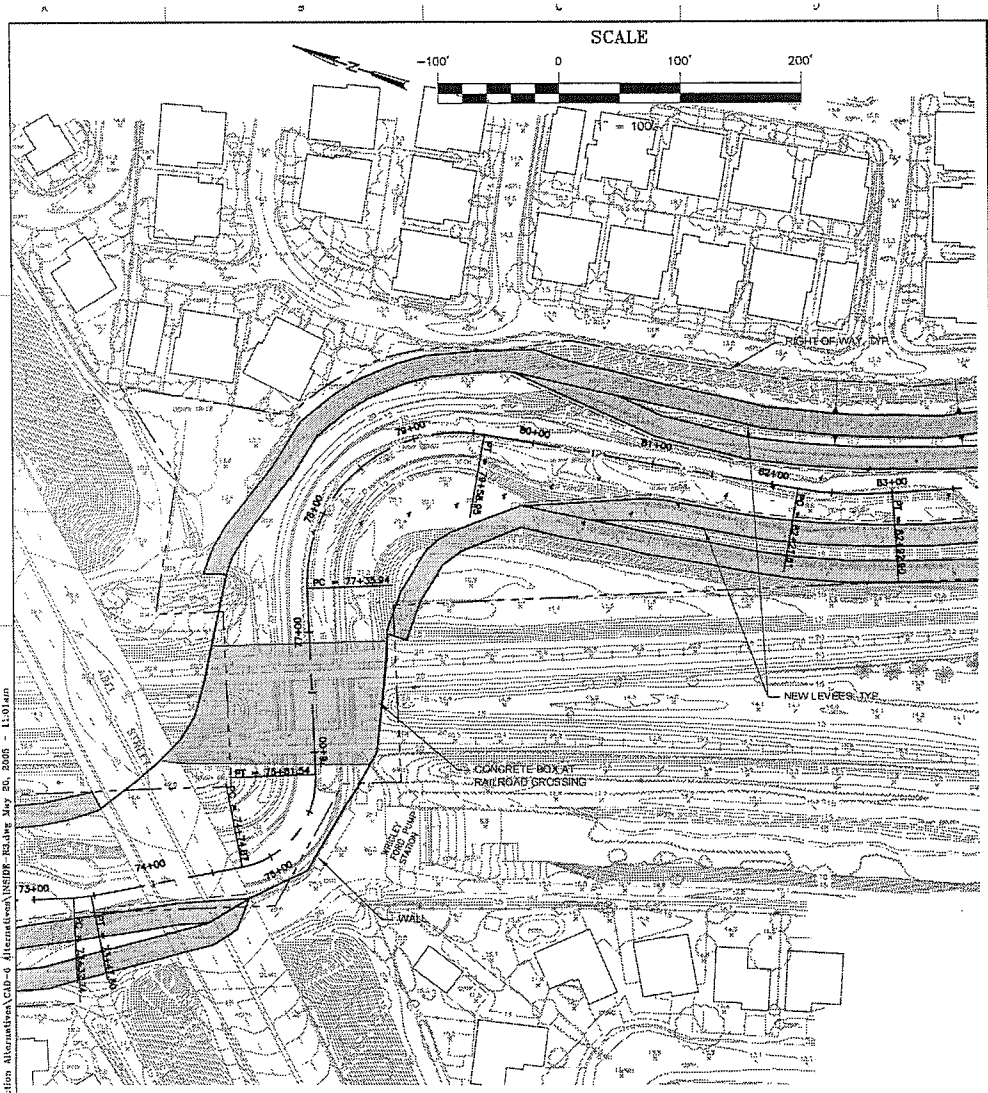
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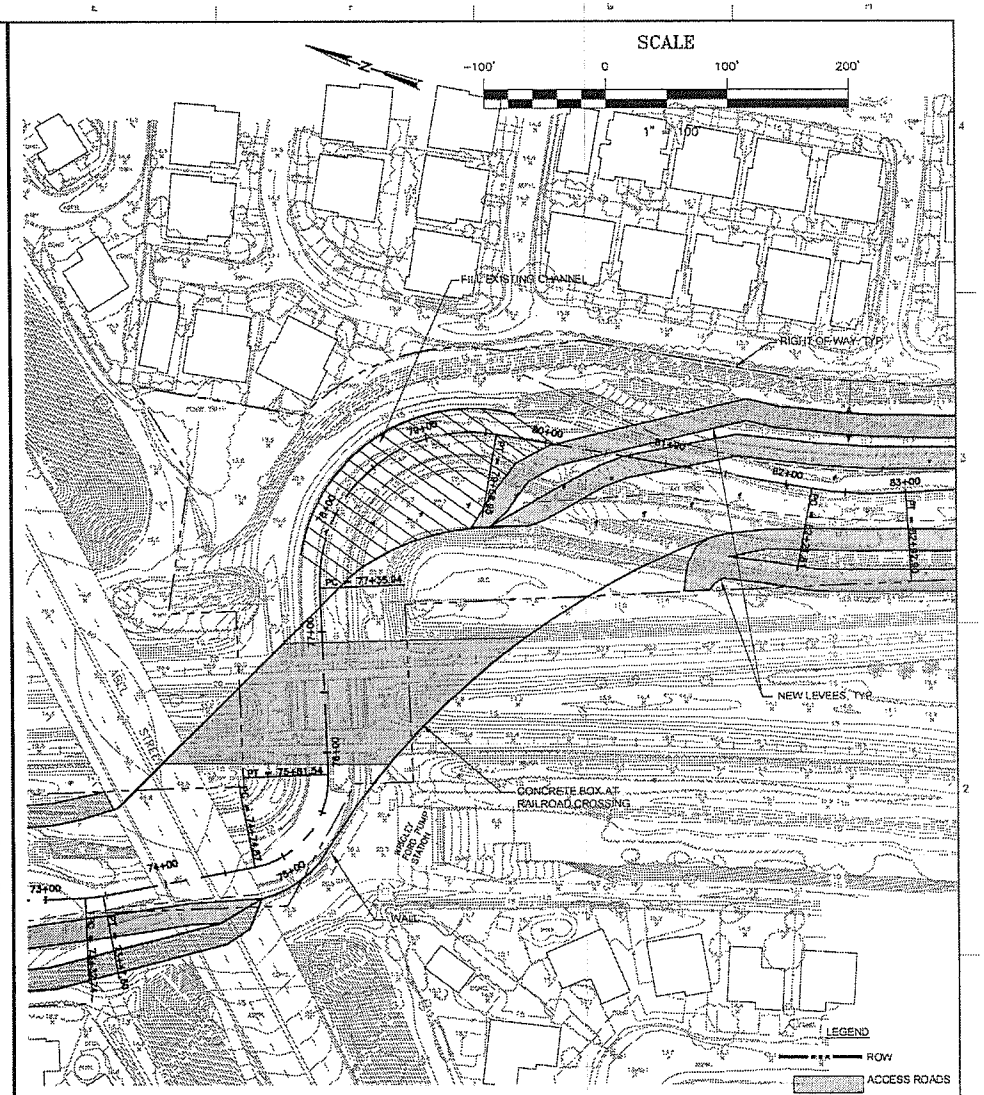
1 OF 28

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SCALE
100' 0 100 200'
RIGHT OF WAY, TYP
NEW LEVEES TYP
ABEL STREET
61+00
62+00
63+00
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65+00
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67+00
68+00
69+00
70+00
71+00
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92+00
93+00
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ALTERNATIVE 1



ALTERNATIVE 2

NOTE:
STATIONING BASED ON EXISTING CENTER LINE OF CHANNEL.

FIGURE-1

REV	DESCRIPTION	DATE	APPR

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CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 823-1010
P.O. BOX 8705, SANTA ROSA, CA 95405 FAX (707) 527-8679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District

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LEVEES WITHIN ROW ALTERNATIVE
ALTERNATIVE 1&2
BERRYESSA CREEK LEVEES PROJECT

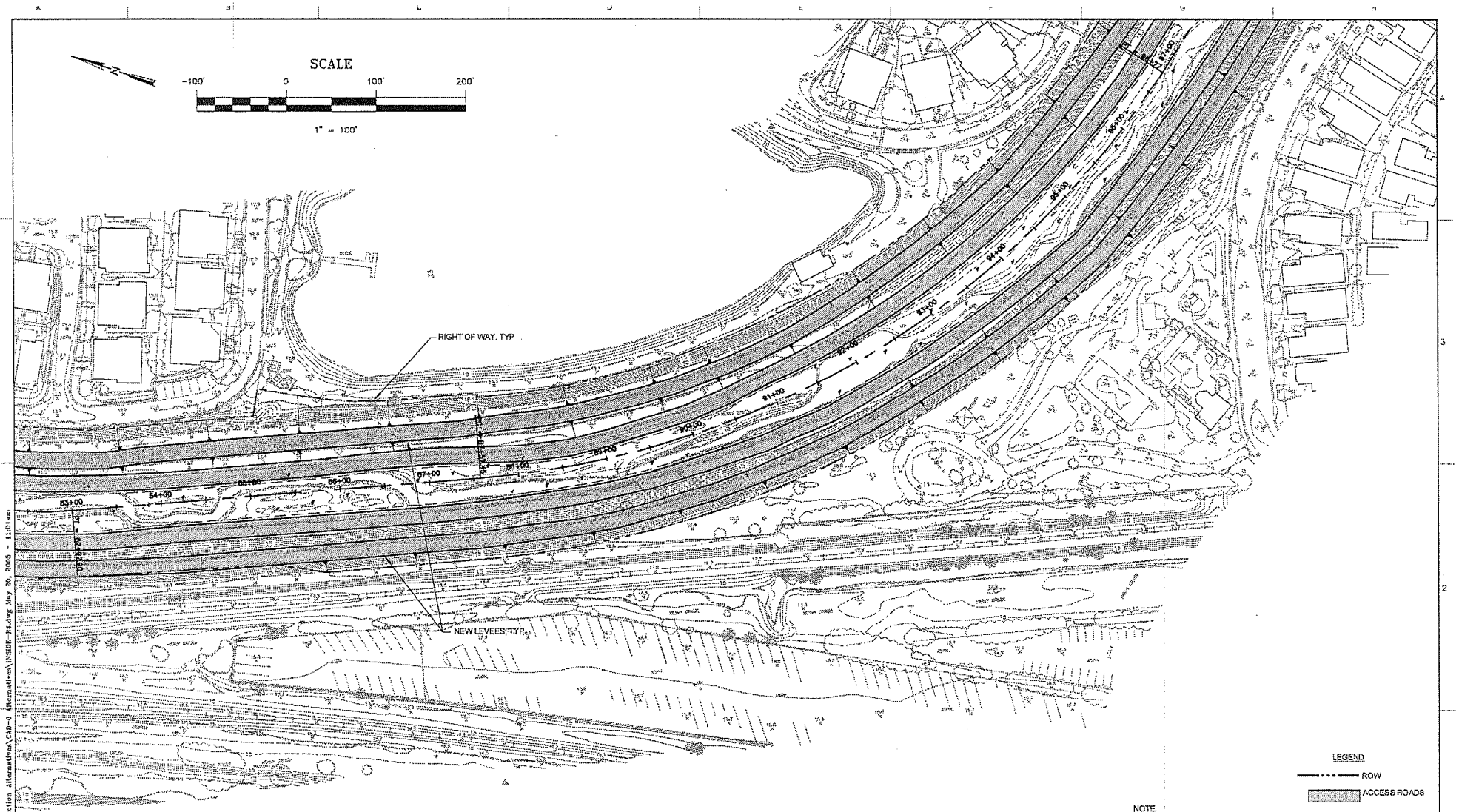
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SCALE SHOWN

SHEET IR-3

3 OF 26

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NOTE
STATIONING BASED ON EXISTING CENTER LINE OF CHANNEL.

FIGURE-1

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 11765, SANTA ROSA, CA 95406 FAX (707) 527-9679

DATE	2/4/04
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CHECKED	R. J.

Santa Clara Valley Water District
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DATE

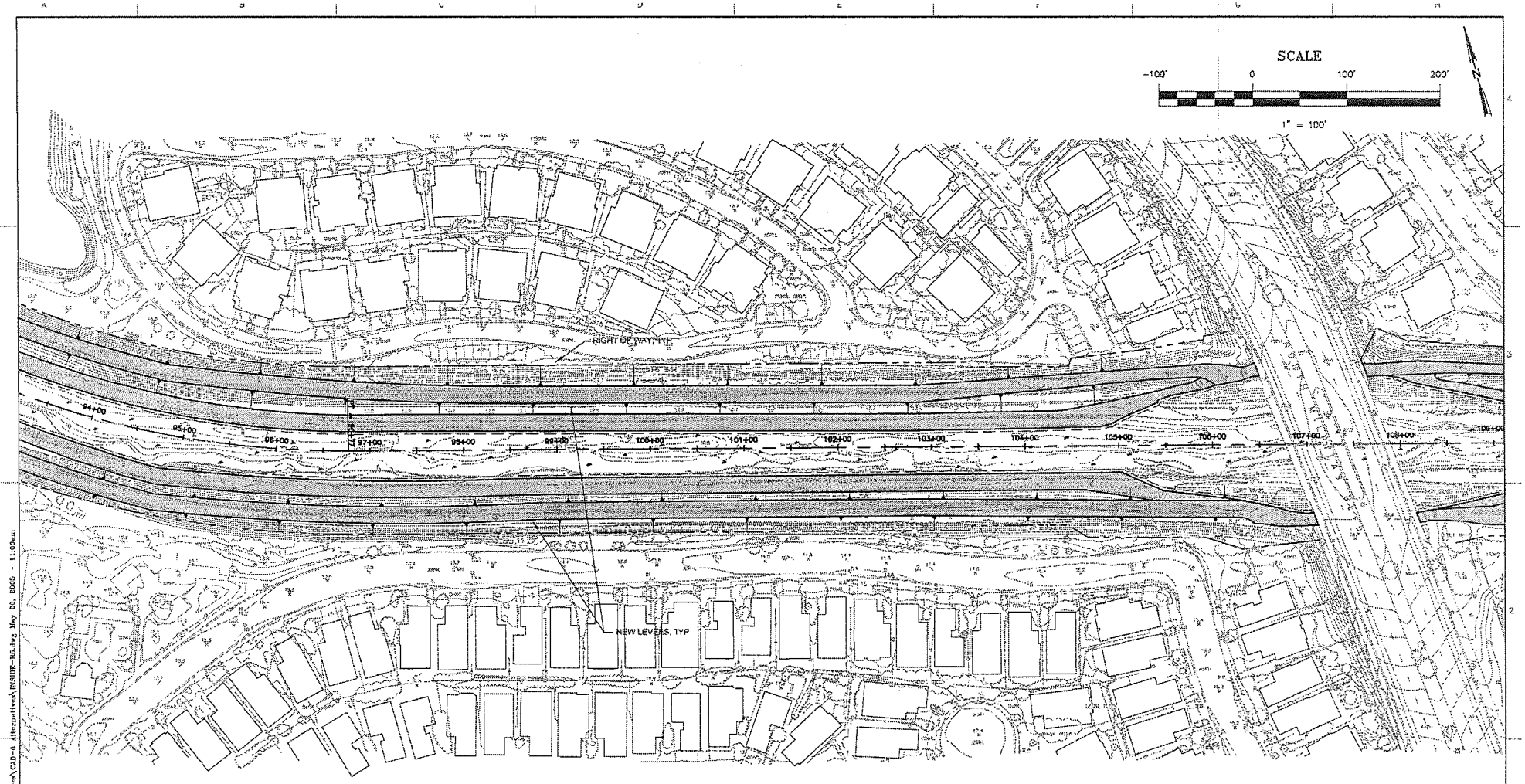
LEVEES WITHIN ROW ALTERNATIVE
ALTERNATIVE 1&2
BERRYESSA CREEK LEVEES PROJECT

VERIFY SCALES
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SCALE SHOWN

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IR-4
4 OF 26

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NOTE:
STATIONING BASED ON EXISTING CENTER LINE OF CHANNEL.

LEGEND
ROW
ACCESS ROADS

FIGURE-1

REV	DESCRIPTION	DATE	APPR

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P.O. BOX 8795, SANTA ROSA, CA 95408
PH (707) 523-1010
FAX (707) 527-8679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

LEVEES WITHIN ROW ALTERNATIVE
ALTERNATIVE 1&2
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
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5 OF 26

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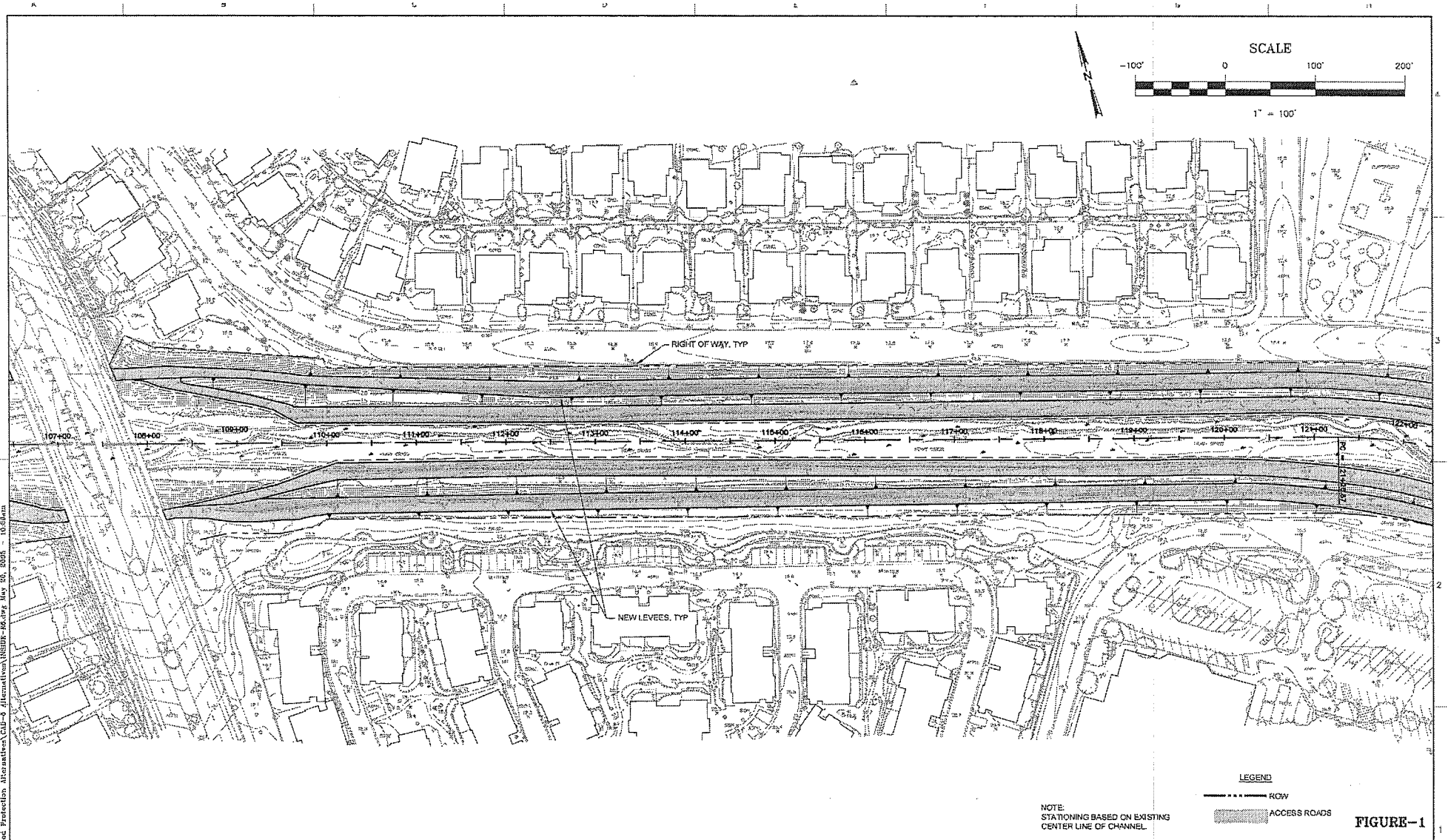


FIGURE-1

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
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DATE	2/1/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District

ACCEPTED BY DISTRICT _____ DATE _____

LEVEES WITHIN ROW ALTERNATIVE
ALTERNATIVE 1&2
BERRYESSA CREEK LEVEES PROJECT

VERIFY SCALES
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SCALE SHOWN

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6 OF 25

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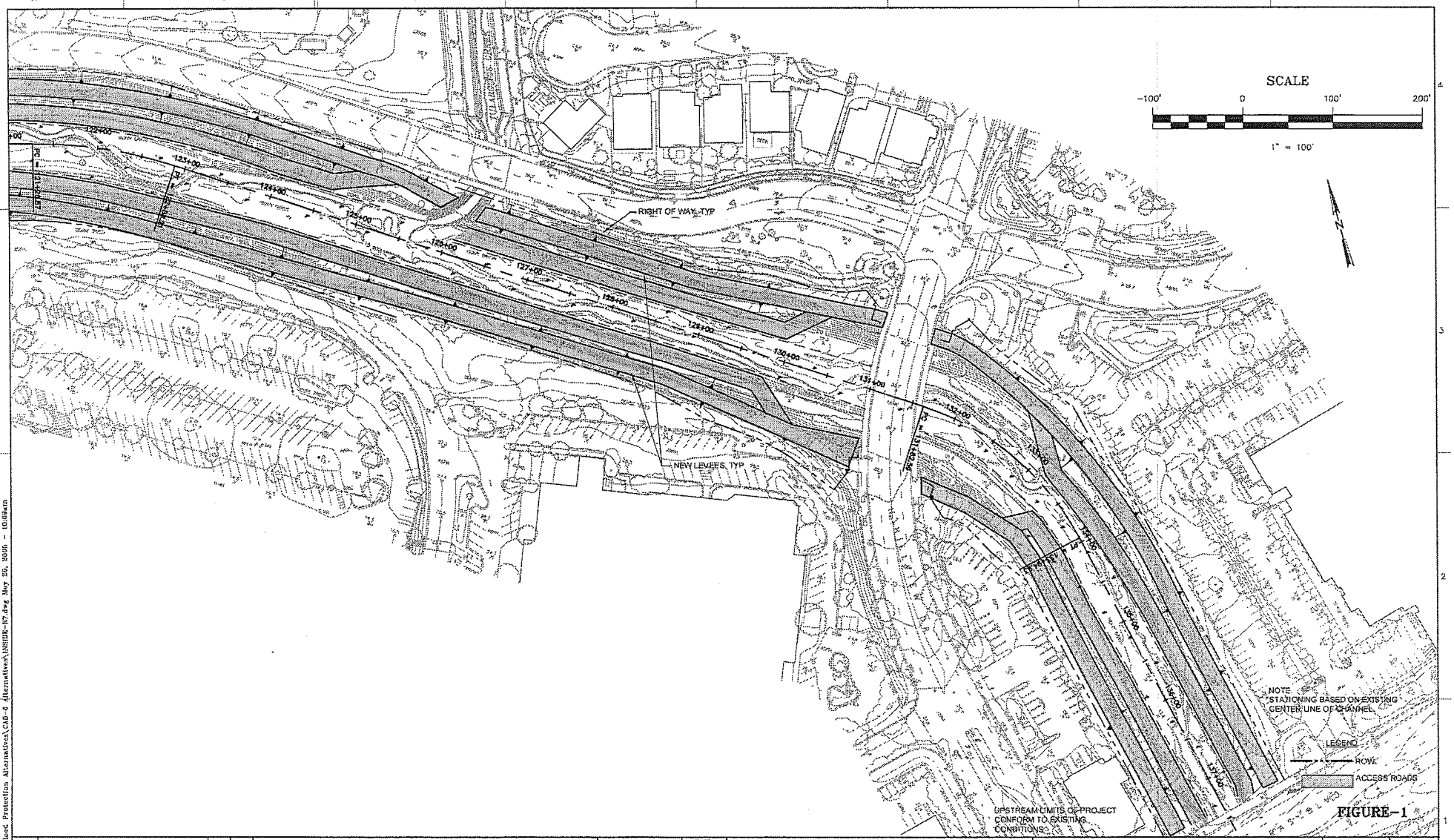


FIGURE-1

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WINZLER & KELLY
CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 522-1010
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DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
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Santa Clara Valley Water District

ACCEPTED BY DISTRICT _____ DATE _____

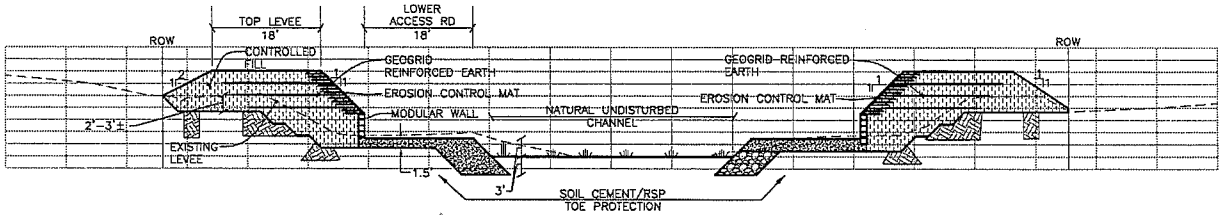
LEVEES WITHIN ROW ALTERNATIVE
ALTERNATIVE 1&2
BERRYESSA CREEK LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
IR-7
7 OF 26

A:\DWG\245101\IR- Flood Protection Alternatives\CAD-6 Alternatives\INSIDE-R7.dwg May 20, 2005 - 10:09am



TYPICAL LEVEE SECTION (WITHIN ROW)

1"=10' 10' 5' 0 10' 20' 30' 40'

FIGURE-2

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401
P.O. BOX 8798, SANTA ROSA, CA 95406
PH (707) 523-1010
FAX (707) 527-8679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District

ACCEPTED BY DISTRICT

DATE

LEVEES WITHIN ROW ALTERNATIVE
ALTERNATIVE 1&2
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
IR-8
8 OF 26

J:\01\24101\13- Flood Protection Alternatives\CAD-8 alternatives\NRSIDE-R8.dwg May 20, 2005 - 2:57pm

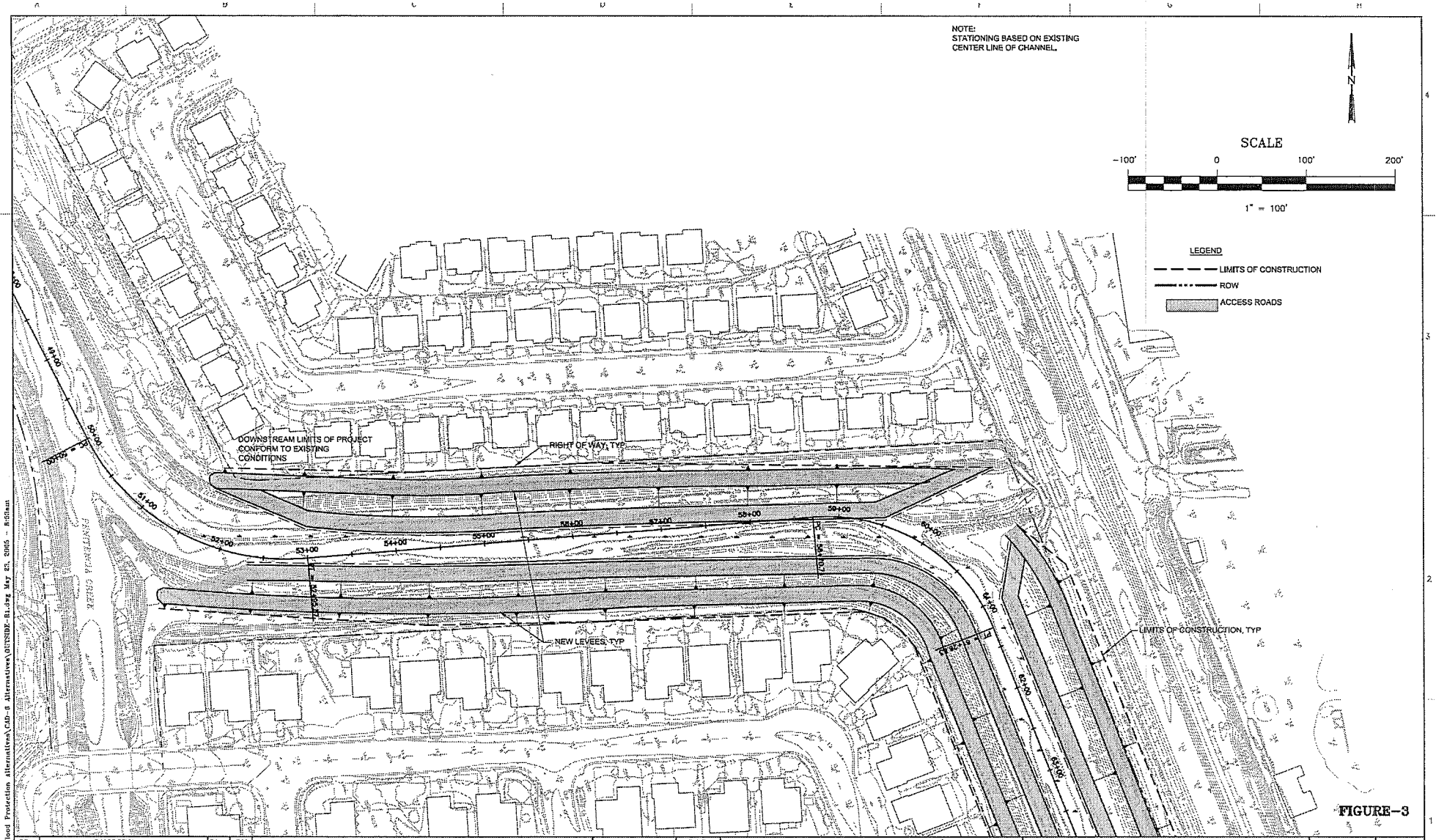


FIGURE-3

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
403 FEDERAL CIRCLE, SANTA ROSA, CA 95401 Ph (707) 523-1010
P.O. BOX 9796, SANTA ROSA, CA 95405 FAX (707) 527-6679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

LEVEES OUTSIDE ROW ALTERNATIVE
ALTERNATIVE 3 & 4
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
OR-1
9 OF 26

J:\01\64510\13- Flood Protection Alternatives\CAD-B Alternatives\OUTSIDE-R1.dwg May 25, 2005 - 8:50am

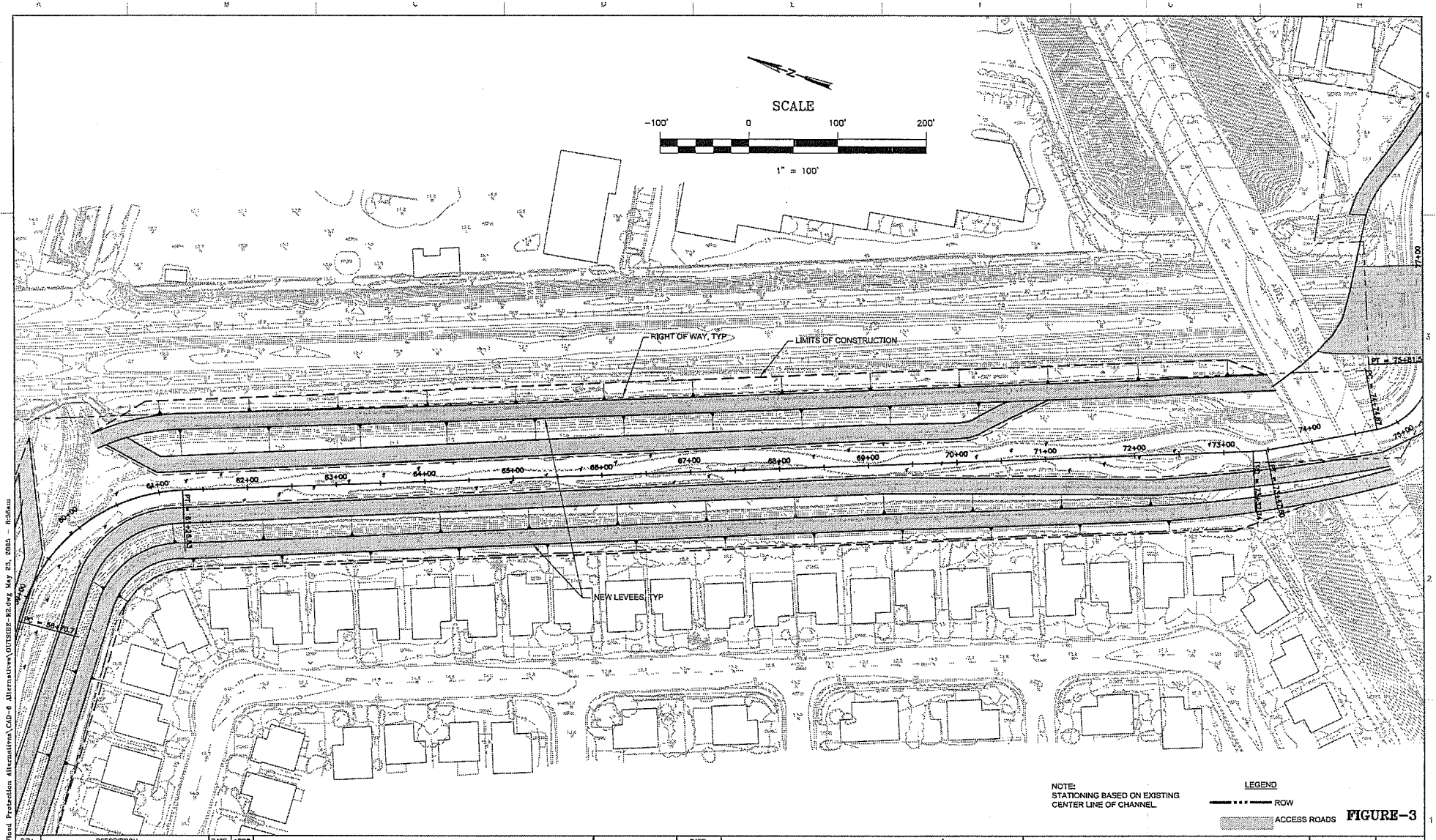


FIGURE-3

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
493 TESCONI CIRCLE, SANTA ROSA, CA 95401
P.O. BOX 6735, SANTA ROSA, CA 95406
PH (707) 523-1010
FAX (707) 527-6679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District

ACCEPTED BY DISTRICT

DATE

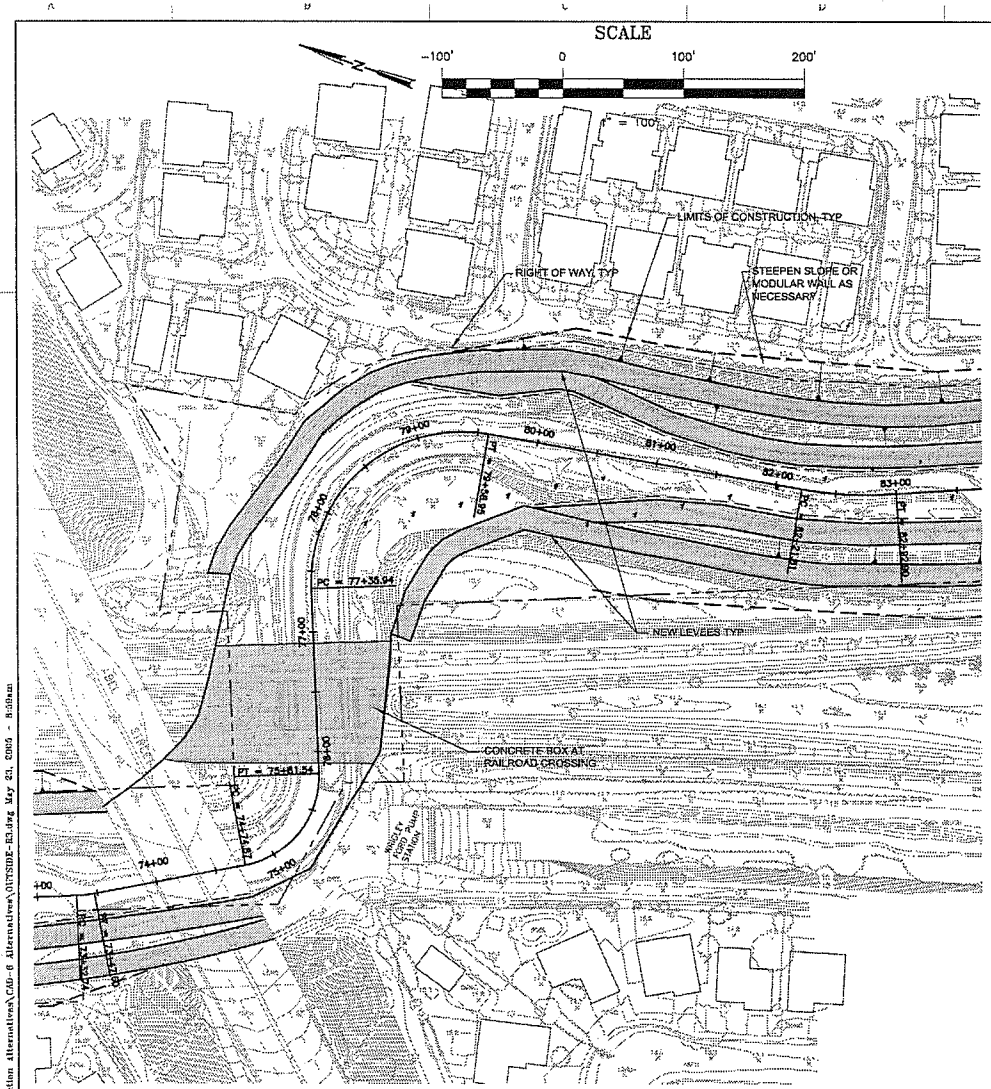
LEVEES OUTSIDE ROW ALTERNATIVE
ALTERNATIVE 3 & 4
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

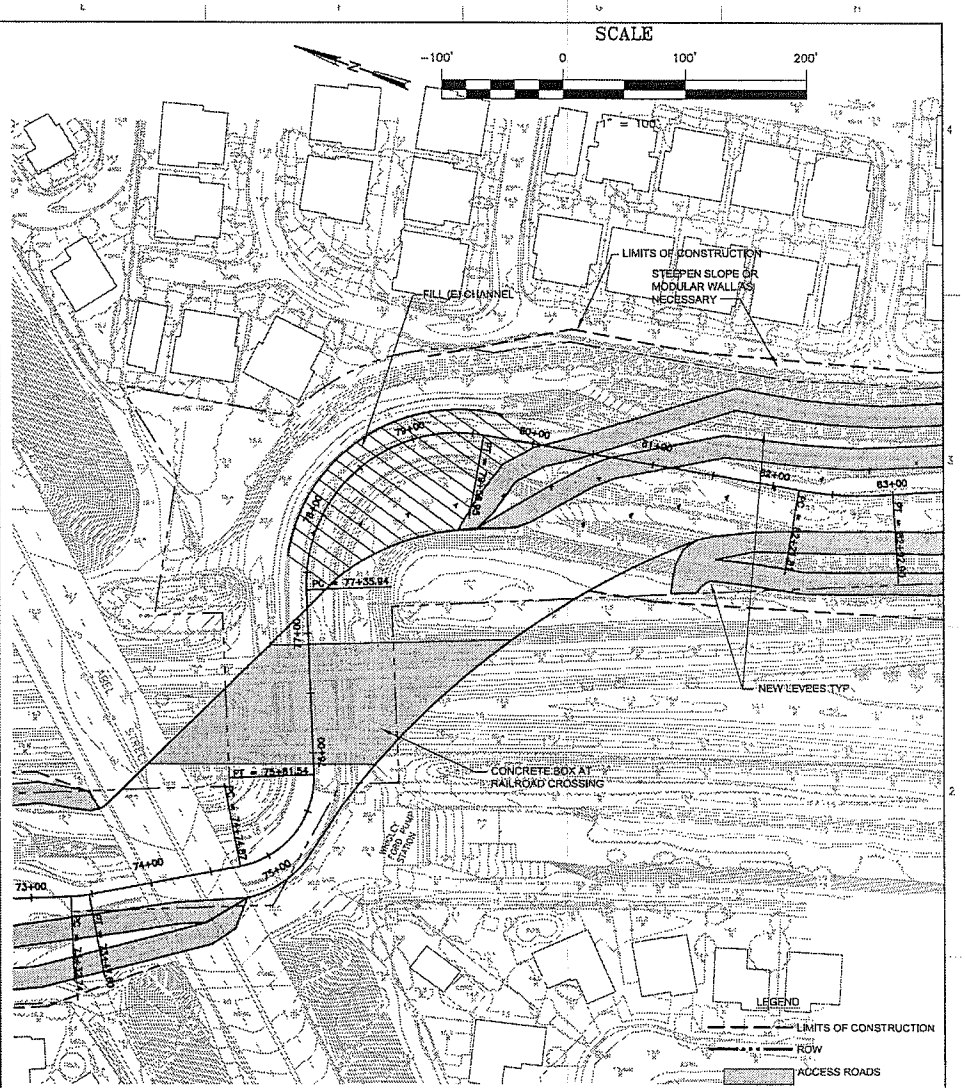
SCALE SHOWN

SHEET
OR-2
10 OF 26

J:\01\24\101\13 - Flood Protection Alternatives\CAD - 6 Alternatives\OUTSIDE-R2.dwg May 25, 2005 - Richard



ALTERNATIVE 3



ALTERNATIVE 4

NOTE:
STATIONING BASED ON EXISTING CENTER LINE OF CHANNEL.

FIGURE-3

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
493 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 8795, SANTA ROSA, CA 95406 FAX (707) 527-0879

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District

ACCEPTED BY DISTRICT _____ DATE

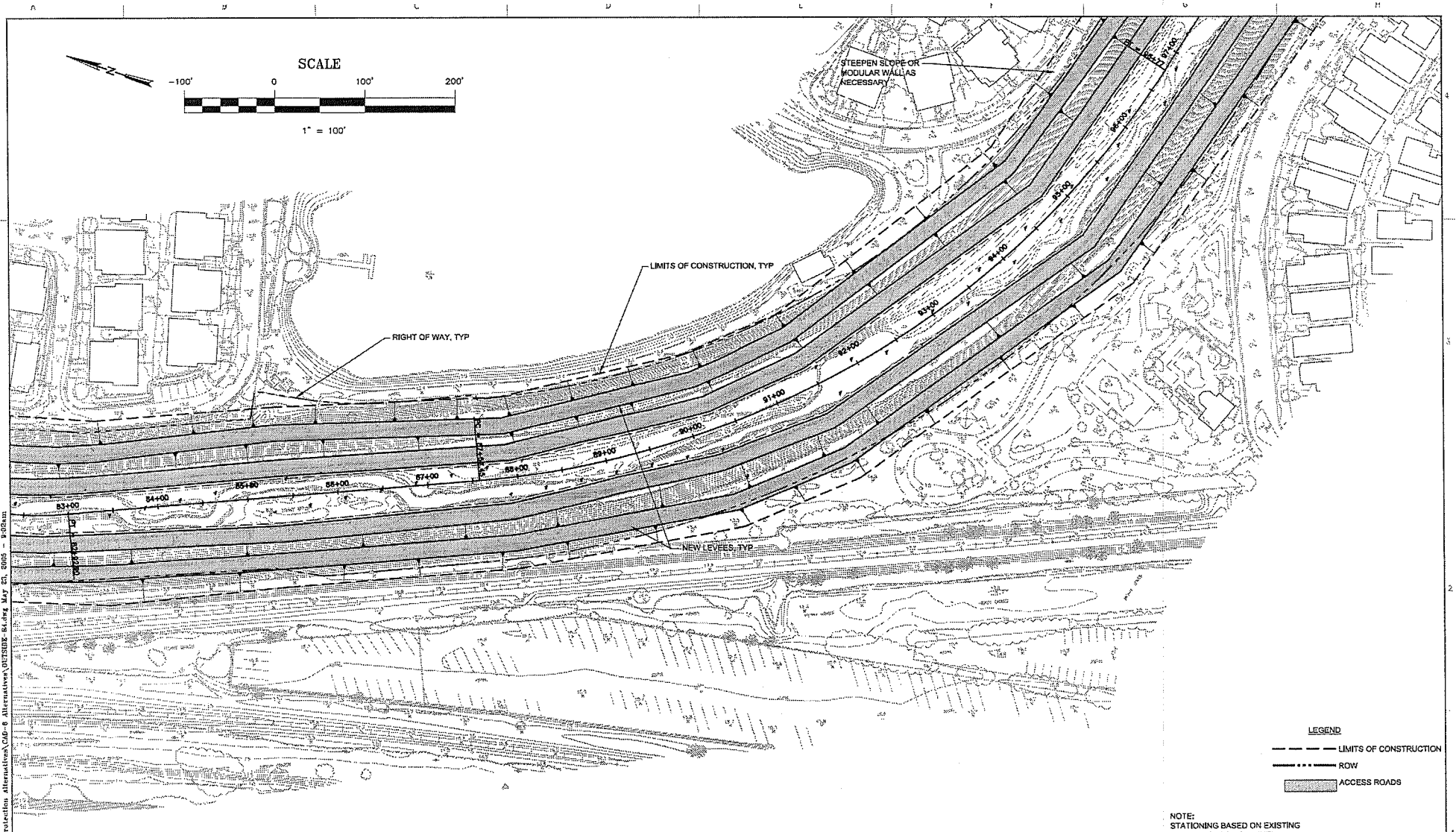
LEVEES OUTSIDE ROW ALTERNATIVE
ALTERNATIVE 3 & 4
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
OR-3
11 OF 26

J:\01\2d1601\13- Flood Protection Alternatives\CAD-6 Alternatives\OUTSIDE-R3.dwg May 21, 2005 - Bodman



NOTE:
STATIONING BASED ON EXISTING CENTER LINE OF CHANNEL.

FIGURE-3

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
493 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 9788, SANTA ROSA, CA 95406 FAX (707) 527-8679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT _____ DATE _____

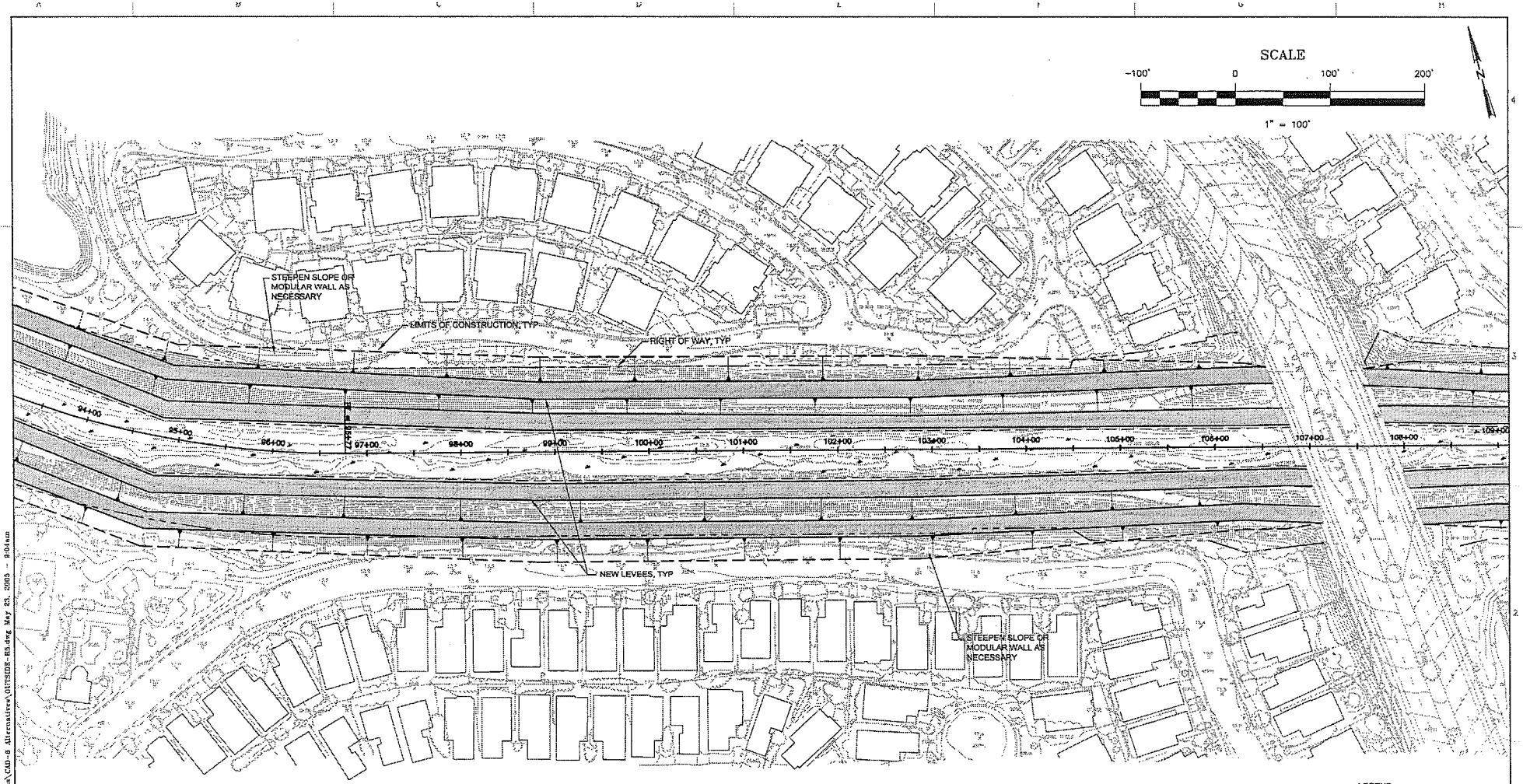
LEVEES OUTSIDE ROW ALTERNATIVE
ALTERNATIVE 3 & 4
BERRYESSA CREEK LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
OR-4
12 OF 26

J:\01\26101\13 - Flood Protection Alternatives\CAD - 6 Alternatives\OUTSIDE-04.dwg May 27, 2005 - 9:02am



FIGURE–3

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
493 TECONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 8795, SANTA ROSA, CA 95406 FAX (707) 527-6679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT _____ DATE _____

LEVEES OUTSIDE ROW ALTERNATIVE
ALTERNATIVE 3 & 4
BERRYESSA CREEK LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
OR–5
13 OF 26

J:\01\24510\13- Flood Protection Alternatives\CAD-8 Alternatives\OUTSIDE-R5.dwg May 25, 2005 - 8:04am

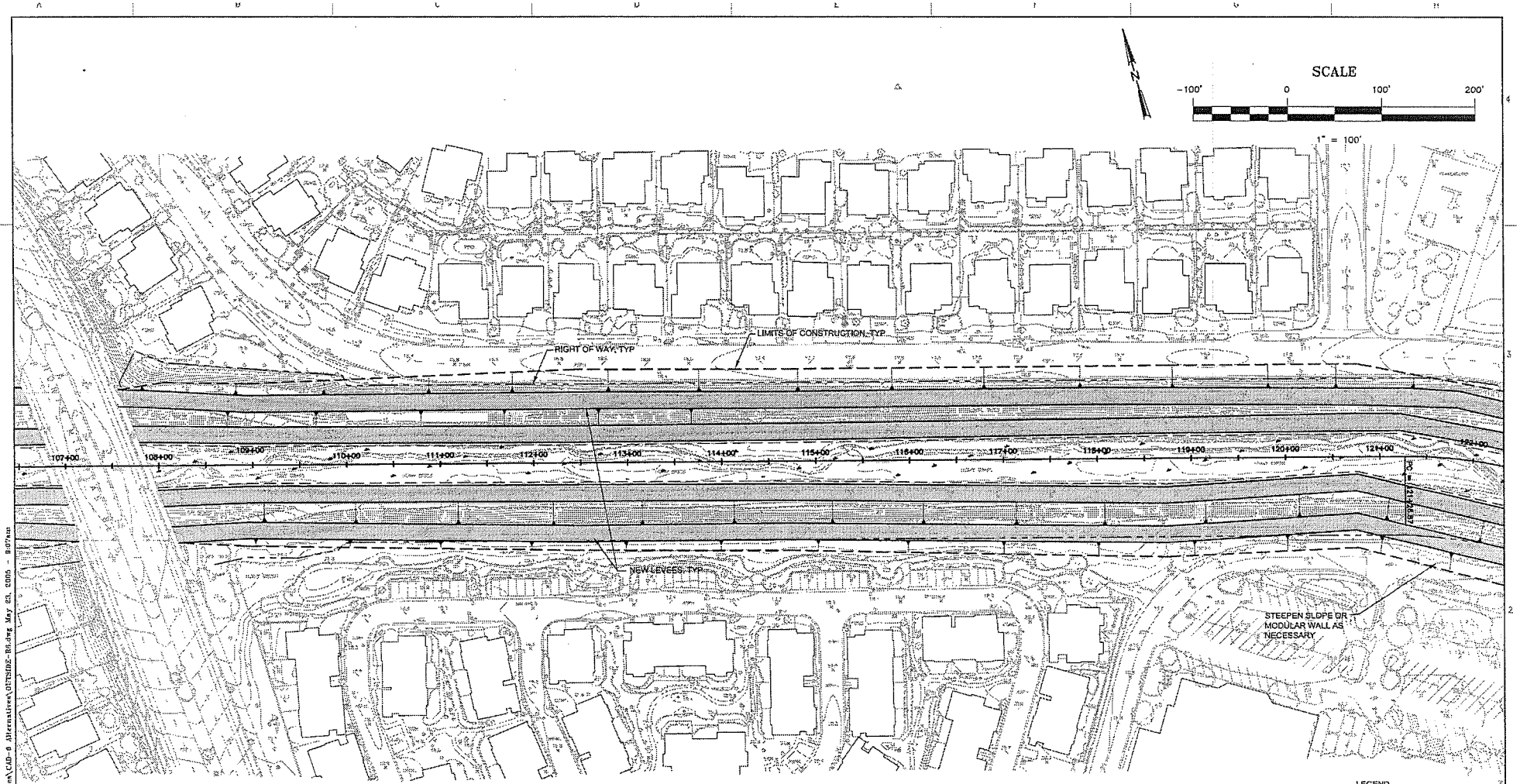


FIGURE-3

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
403 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 8795, SANTA ROSA, CA 95406 FAX (707) 527-6572

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

LEVEES OUTSIDE ROW ALTERNATIVE
ALTERNATIVE 3 & 4
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
OR-6
14 OF 28

J:\01\24610\13 - Flood Protection Alternatives\CAD-8 Alternatives\OUTSIDE-R6.dwg May 25, 2005 - 8:07am



FIGURE-3

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
405 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 9758, SANTA ROSA, CA 95406 FAX (707) 527-6679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District

ACCEPTED BY DISTRICT _____ DATE _____

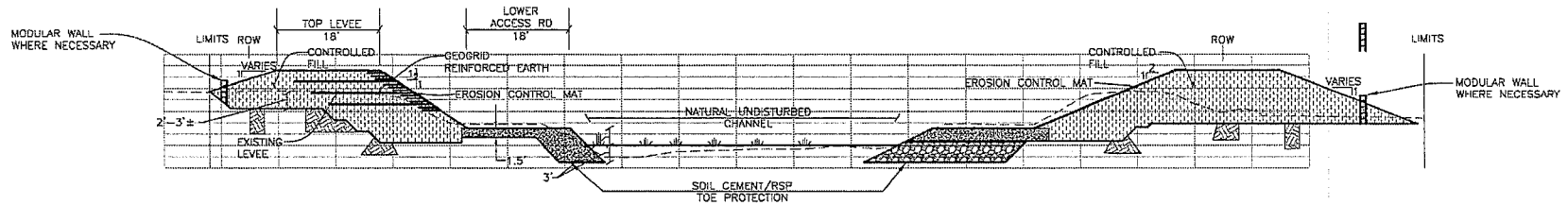
LEVEES OUTSIDE ROW ALTERNATIVE
ALTERNATIVE 3 & 4
BERRYESSA CREEK LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET OR-7
15 OF 26

J:\01\2461\01\13- Flood Protection Alternatives\CAD-8 Alternatives\OUTSIDE-R7.dwg May 25, 2005 - 9:10am



TYPICAL LEVEE SECTION (OUTSIDE ROW)

1"=10' 10' 5' 0 10' 20' 30' 40'

FIGURE-4

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 8795, SANTA ROSA, CA 95406 FAX (707) 527-8679

DATE 2/4/04
DESIGN R. J.
DRAWN T. P.
CHECKED R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

LEVEES OUTSIDE ROW ALTERNATIVE
ALTERNATIVE 3&4
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN
SHEET
OR-8
16 OF 26

J:\01\24101\13- Flood Protection Alternatives\CAD-8 Alternatives\OUTSIDE-R8.dwg May 25, 2005 - 8:16am

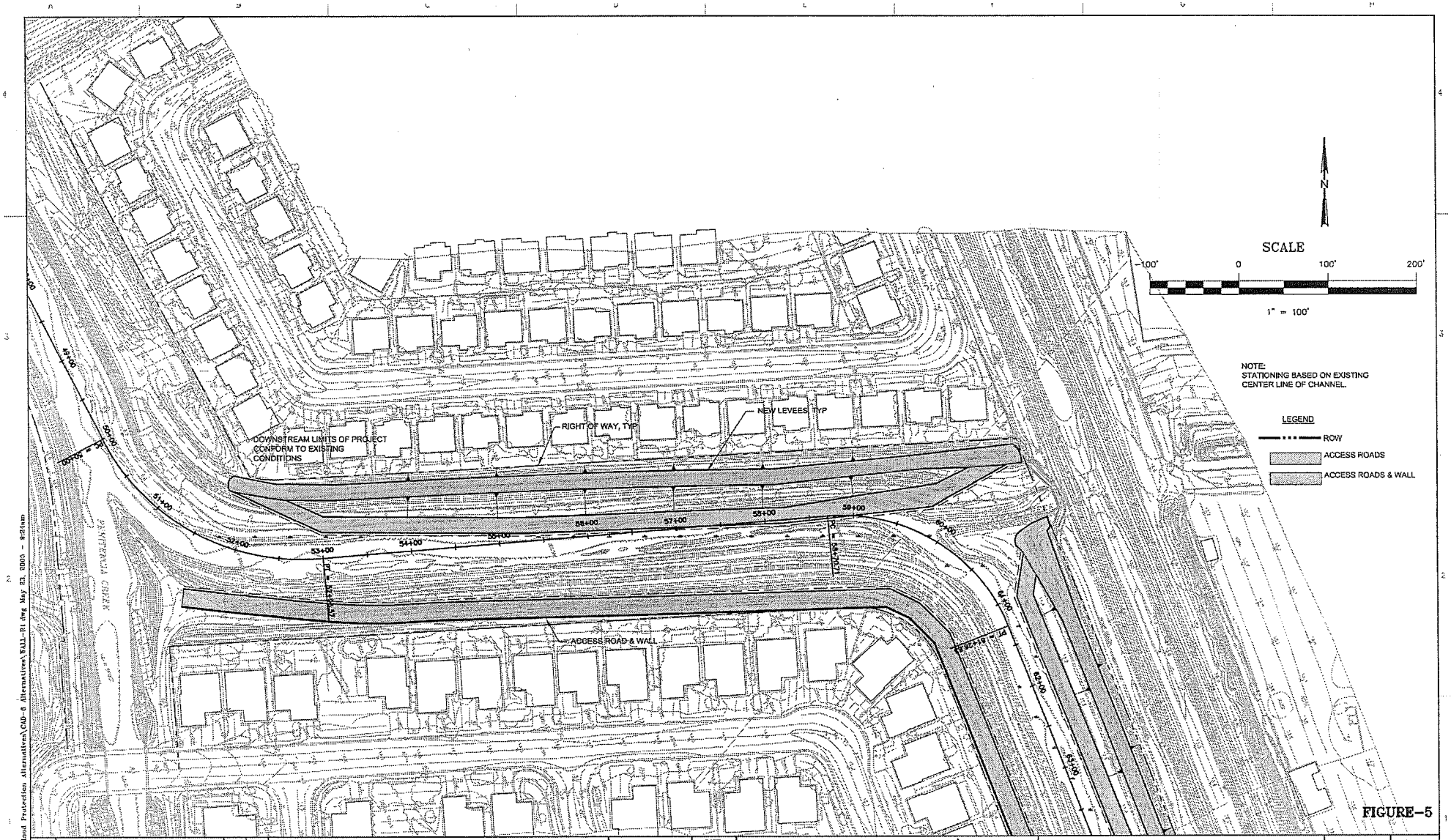


FIGURE-5

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
403 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 8795, SANTA ROSA, CA 95406 FAX (707) 527-6578

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District

ACCEPTED BY DISTRICT _____ DATE _____

K CHANNEL ALTERNATIVE
ALTERNATIVE 5
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
KC-1
17 OF 26

J:\01\84101\13- Flood Protection Alternatives\CAD-6 Alternatives\FAIL-R1.dwg May 23, 2005 - 9:21am

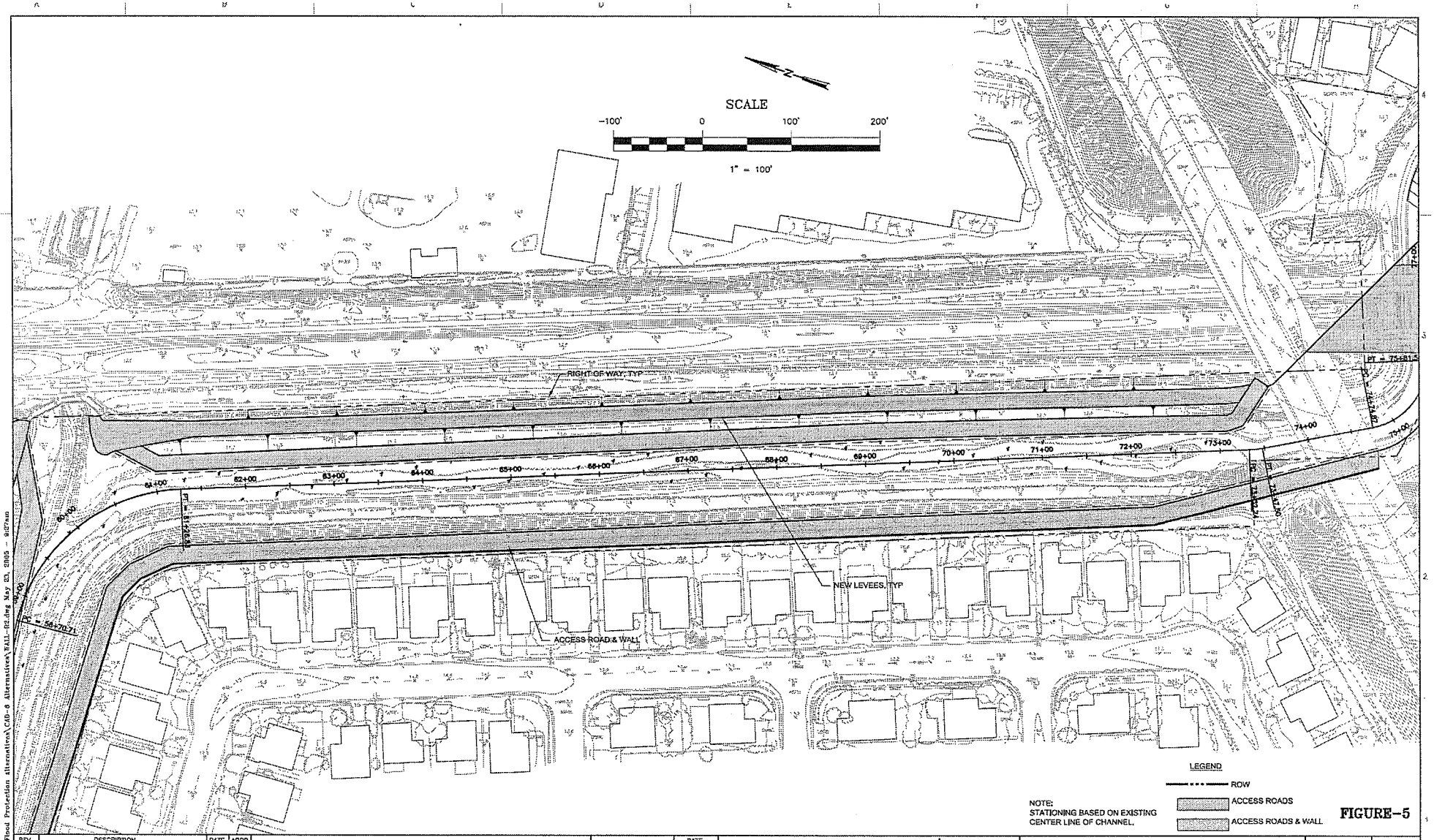


FIGURE-5

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 5796, SANTA ROSA, CA 95402 FAX (707) 527-8679

DATE 2/4/04
DESIGN R. J.
DRAWN T. P.
CHECKED R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

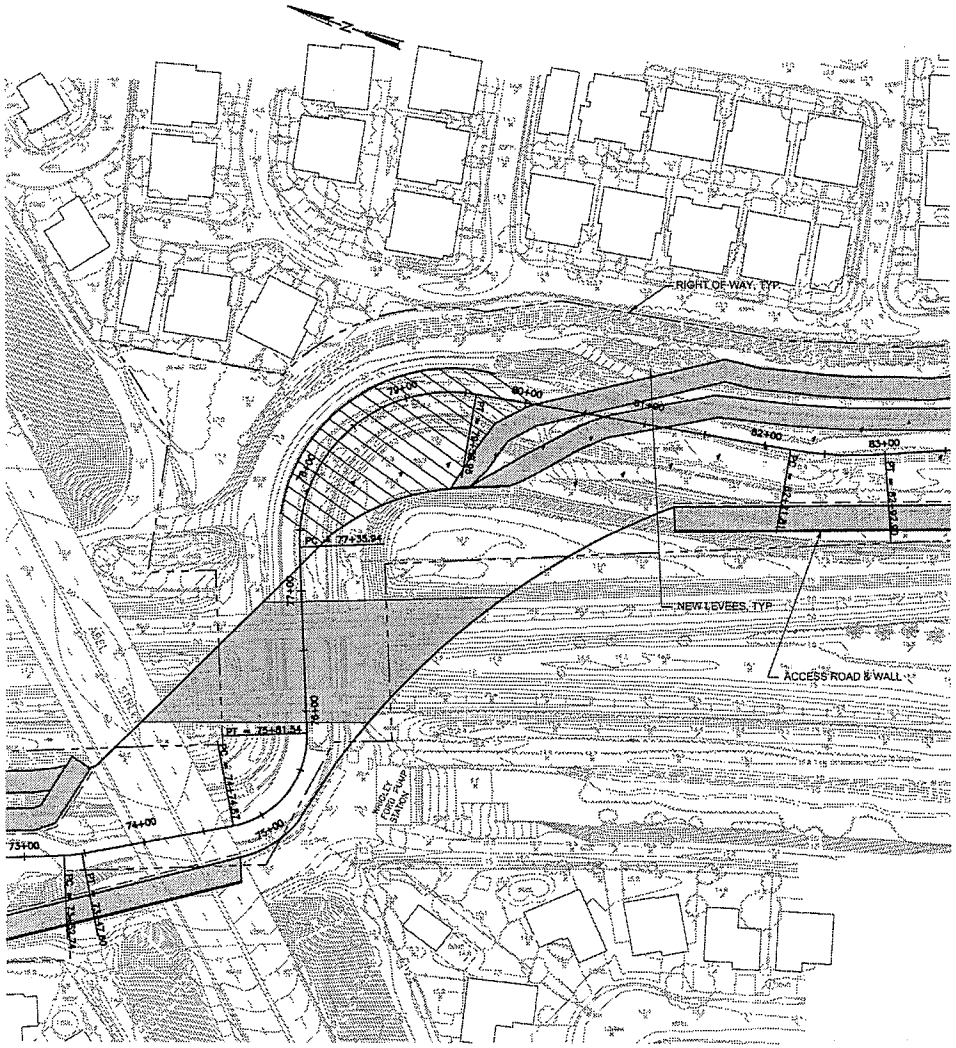
K CHANNEL ALTERNATIVE
ALTERNATIVE 5
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET KC-2
18 OF 26

J:\01\2461101\13 - Flood Protection alternatives\CAD-5 Alternatives\FALL-02.dwg May 03, 2005 - 9:27am



SCALE

-100' 0 100' 200'

1" = 100'

LEGEND

ROW

ACCESS ROADS

ACCESS ROADS & WALL

NOTE:
STATIONING BASED ON EXISTING CENTER LINE OF CHANNEL

FIGURE-5

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
405 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 8795, SANTA ROSA, CA 95406 FAX (707) 527-8679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District

ACCEPTED BY DISTRICT _____ DATE _____

K CHANNEL ALTERNATIVE
ALTERNATIVE 5
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET KC-3
19 OF 26

J:\01\245101\13 - Flood Protection Alternatives\CAD-6 Alternatives\FALL-ED.dwg May 23, 2005 - 9:28am

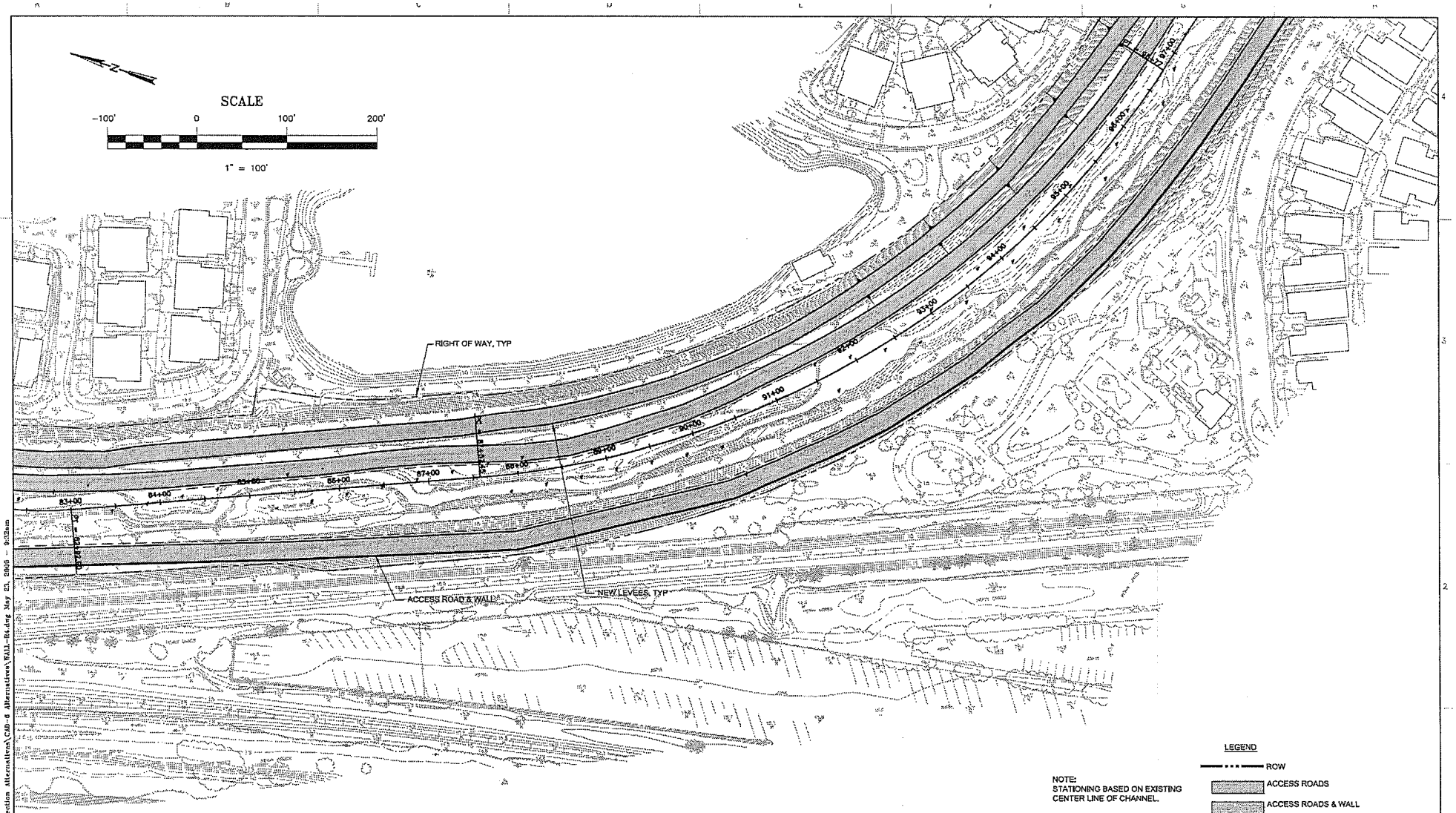


FIGURE-5

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
405 FESCONI CIRCLE, SANTA ROSA, CA 95401 Ph (707) 523-1010
P.O. BOX 9736, SANTA ROSA, CA 95406 FAX (707) 527-8679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT _____ DATE _____

K CHANNEL ALTERNATIVE
ALTERNATIVE 5
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
KC-4
20 OF 26

J:\01\24\01\13- Flood Protection Alternatives\CAD-6 Alternatives\WALL-Rx.dwg May 25, 2005 - 9:33am

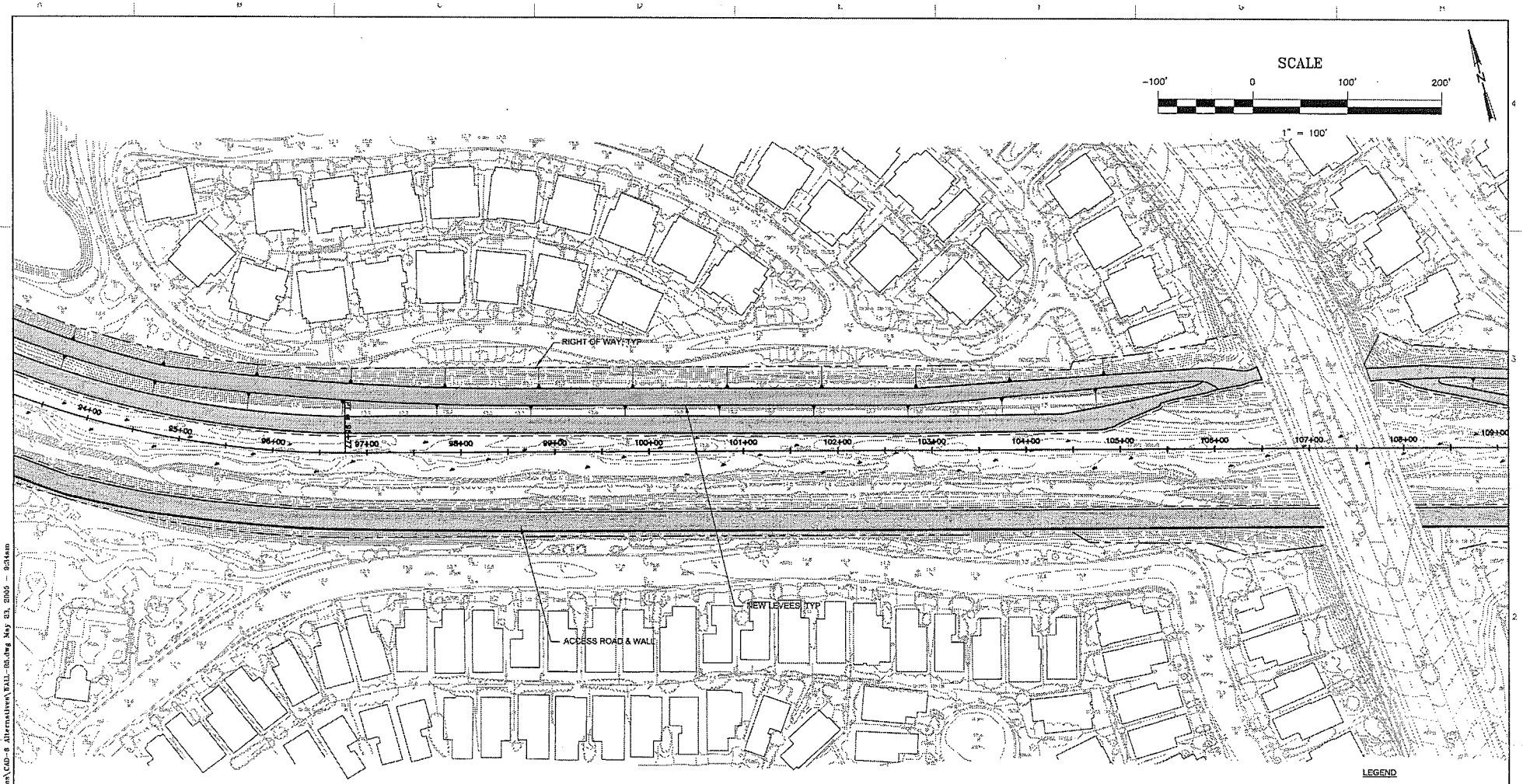


FIGURE-5

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
103 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 9756, SANTA ROSA, CA 95406 FAX (707) 527-6879

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

K CHANNEL ALTERNATIVE
ALTERNATIVE 5
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
KC-5
21 OF 26

J:\01\24610\13 - Flood Protection Alternatives\CAD-8 Alternatives\FALL-05.dwg May 03, 2005 - 9:34am

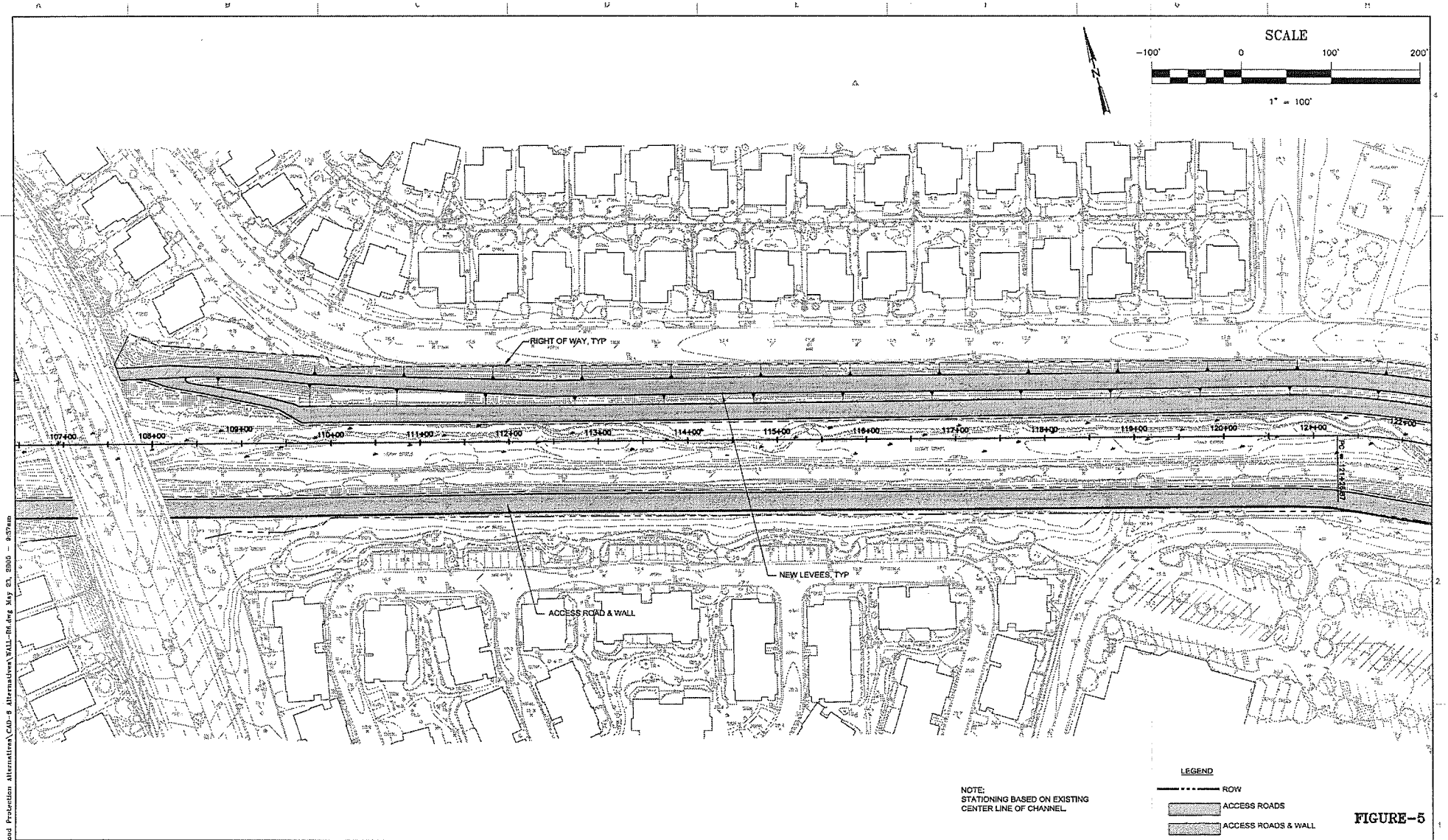


FIGURE-5

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
405 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 8795, SANTA ROSA, CA 95406 FAX (707) 527-6679

DATE	2/4/04
DESIGN	R. J.
DRAWN	T. P.
CHECKED	R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

K CHANNEL ALTERNATIVE
ALTERNATIVE 5
BERRYESSA CREEK LEVEES PROJECT

VERIFY SCALES
0 - 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
KC-6
22 OF 26

J:\01\24510\13- Flood Protection Alternatives\CAD-5 Alternatives\WALL-Rt.dwg May 25, 2005 - 9:37am

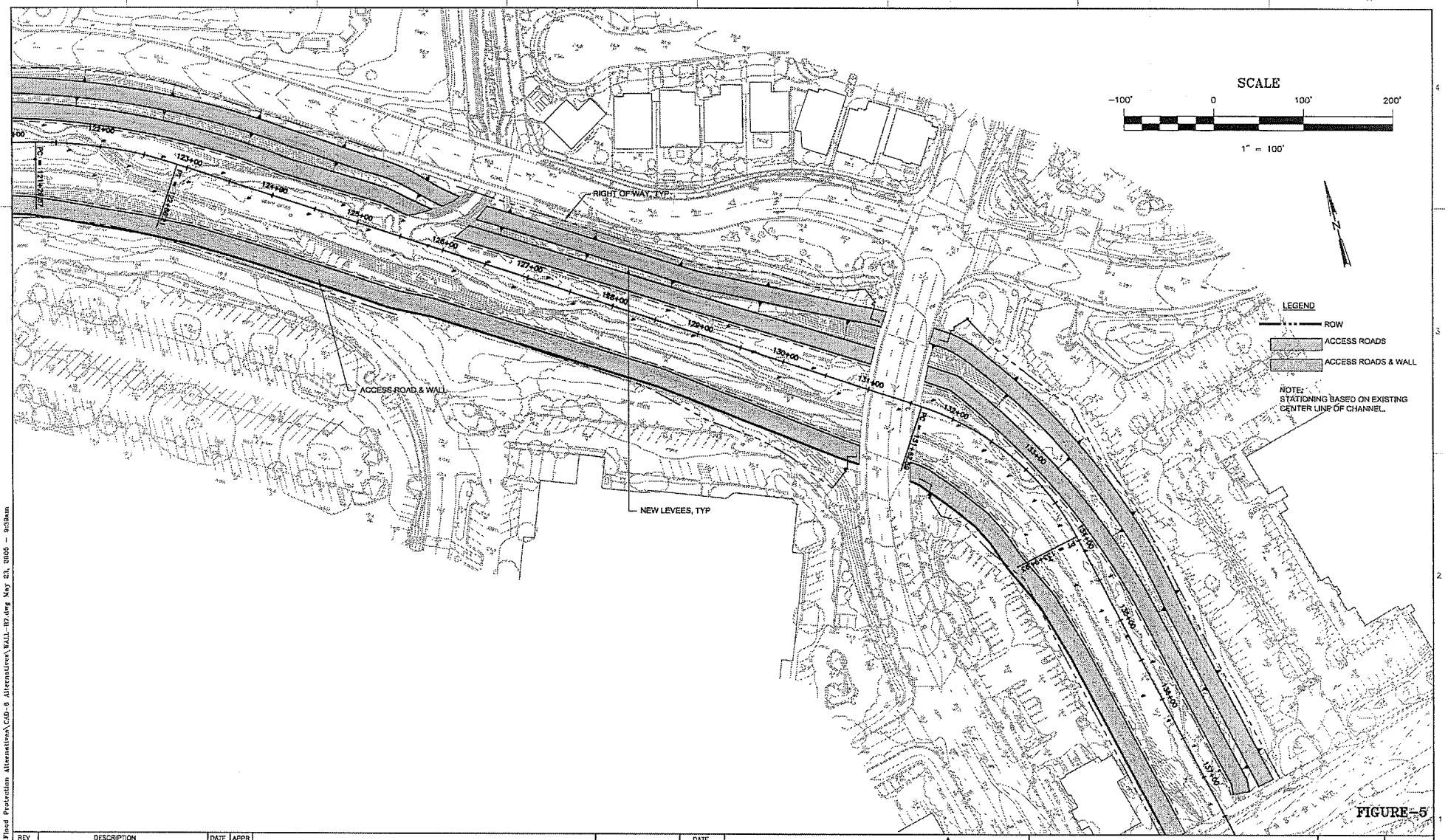


FIGURE-5

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
405 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 8795, SANTA ROSA, CA 95406 FAX (707) 527-0679

DATE 2/4/04
DESIGN R. J.
DRAWN T. P.
CHECKED R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

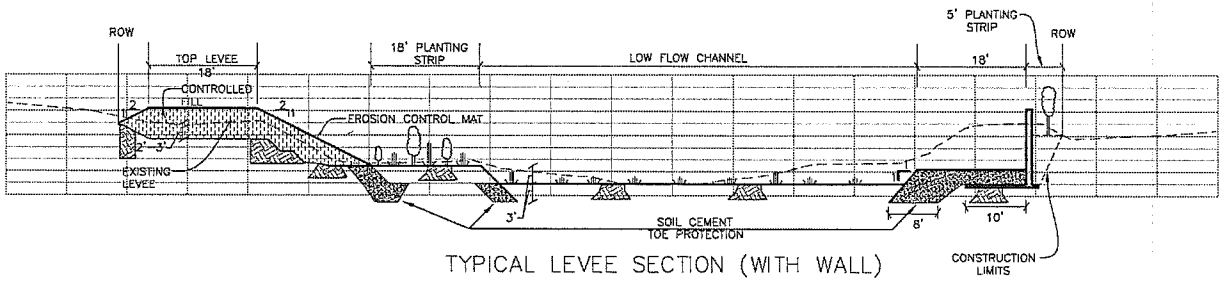
K CHANNEL ALTERNATIVE
ALTERNATIVE 5
BERRYESSA CREEK LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

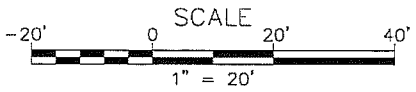
SCALE SHOWN

SHEET
KC-7
23 OF 26

J:\01\24610\13- Flood Protection Alternatives\Cdd-5 Alternatives\FALL-07.dwg May 23, 2005 - 9:58am



TYPICAL LEVEE SECTION (WITH WALL)



FIGURE–6

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
493 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 6798, SANTA ROSA, CA 95406 FAX (707) 527-8679

DATE 2/4/04
DESIGN R. J.
DRAWN T. P.
CHECKED R. J.

Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

K CHANNEL ALTERNATIVE
ALTERNATIVE 5
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

SCALE SHOWN

SHEET
KC–8
OF
B 26

J:\01\24510\13- Flood Protection alternatives\CAD-6 Alternatives\WALL-H8.dwg May 23, 2005 - 9:43am

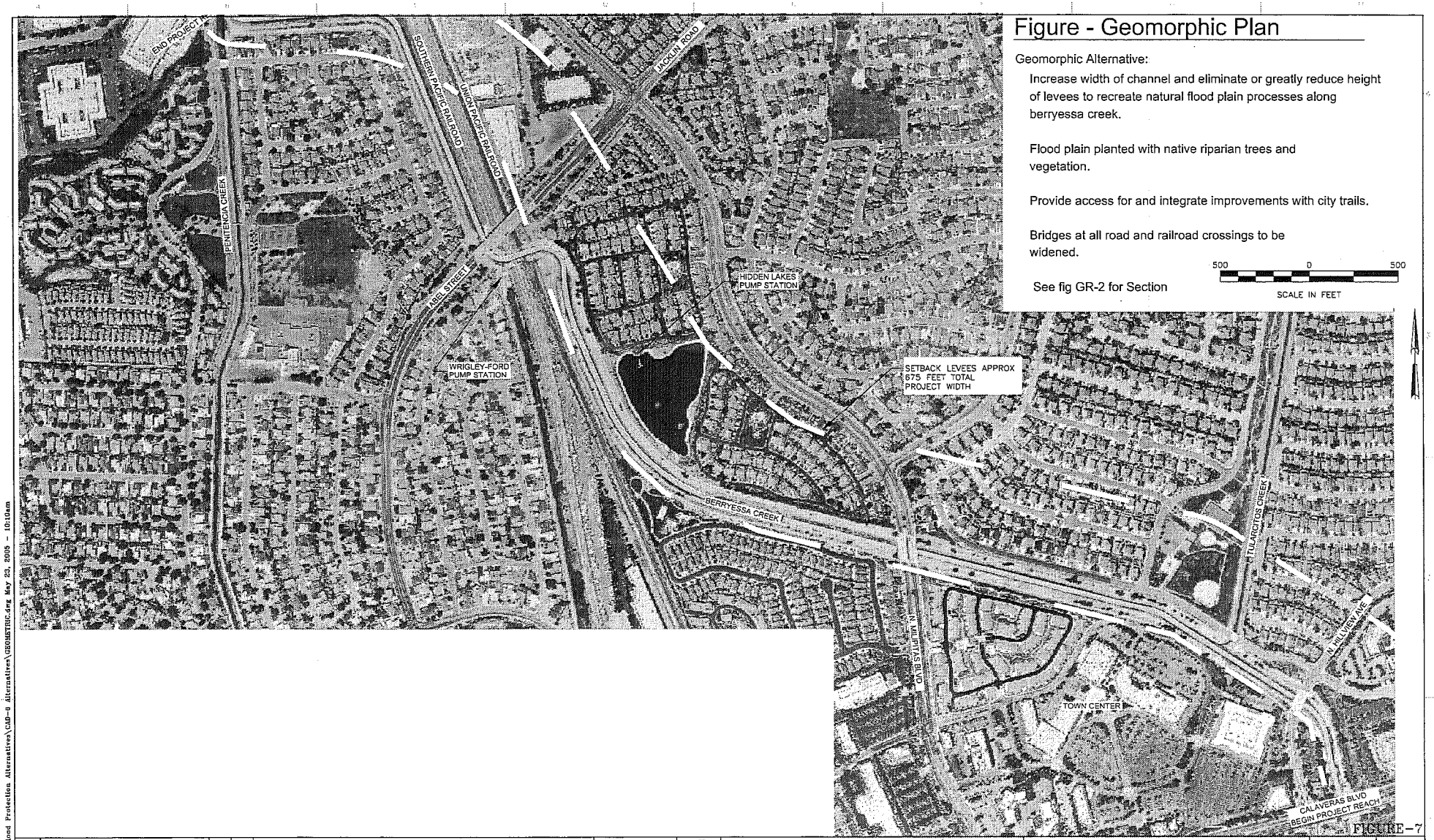


Figure - Geomorphic Plan

Geomorphic Alternative:

Increase width of channel and eliminate or greatly reduce height of levees to recreate natural flood plain processes along berryessa creek.

Flood plain planted with native riparian trees and vegetation.

Provide access for and integrate improvements with city trails.

Bridges at all road and railroad crossings to be widened.

See fig GR-2 for Section

500 0 500

SCALE IN FEET

FIGURE-7

REV	DESCRIPTION	DATE	APPR

WINZLER & KELLY
CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 6798, SANTA ROSA, CA 95406 FAX (707) 527-8679

DATE	
DESIGN	
DRAWN	
CHECKED	

Santa Clara Valley Water District

ACCEPTED BY DISTRICT

DATE

GEOMORPHIC ALTERNATIVE
ALTERNATIVE 6

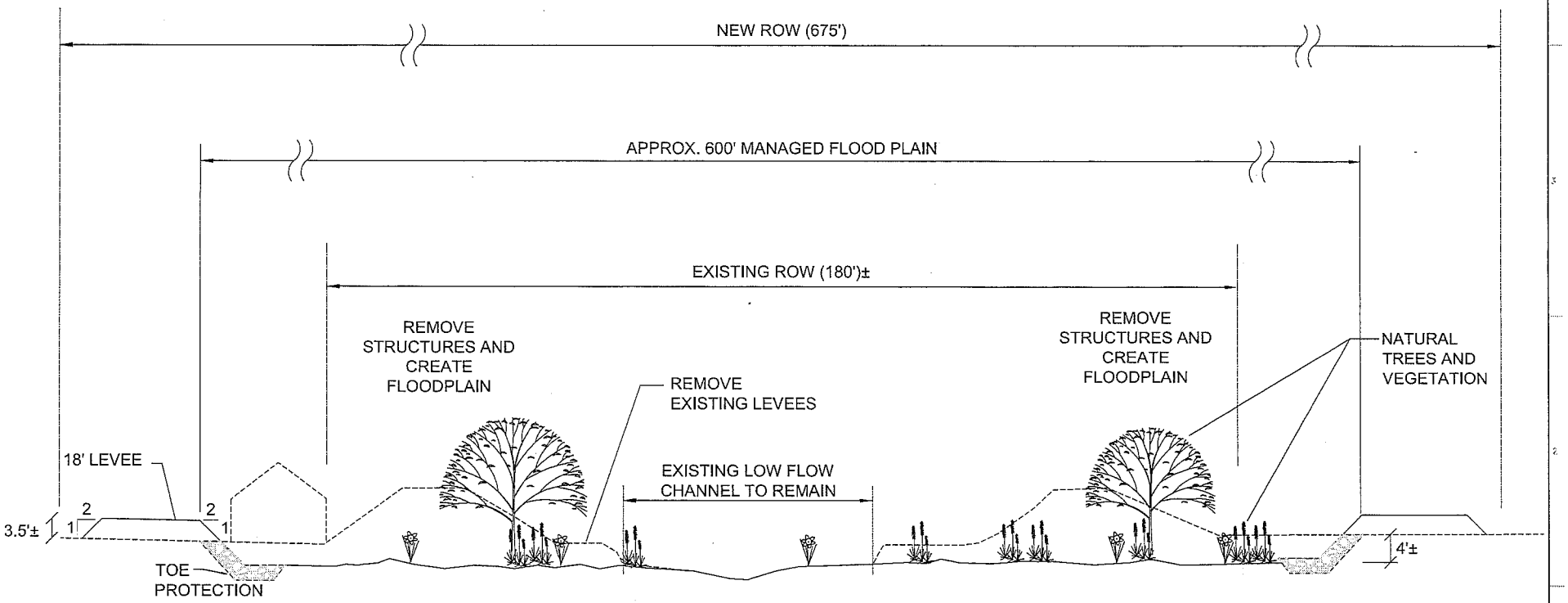
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SCALE

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TYPICAL SECTION

FIGURE-8

REV	DESCRIPTION	DATE	APPR

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CONSULTING ENGINEERS
495 TESCONI CIRCLE, SANTA ROSA, CA 95401 PH (707) 523-1010
P.O. BOX 8798, SANTA ROSA, CA 95406 FAX (707) 527-8679

DATE	
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Santa Clara Valley Water District
ACCEPTED BY DISTRICT
DATE

GEOMORPHIC ALTERNATIVE
ALTERNITAVE 6
BERRYESSA CREEK
LEVEES PROJECT

VERIFY SCALES
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OF

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PRELIMINARY ALTERNATIVE MATRIX

Conceptual Alternatives	Alternative 1 - Raise Levees Within ROW/Widen Railroad	Alternative 2 - Raise Levees Within ROW/Straighten Double	Alternative 3 - Raise Levees Outside ROW/Widen Railroad	Alternative 4 - Raise Levees Outside ROW/Straighten	Alternative 5 - K Channel/Straighten Double 90's	Alternative 6 - Geomorphic Channel
Description of Conceptual Alternatives	Levees will be raised within the existing ROW. The levee top and interior access roads constructed to 18-feet wide. Vertical wall components will be modular walls. Railroad crossing will be widened to approximately 135 feet.	Levees will be raised within the existing ROW. The levee top and interior access roads constructed to 18-feet wide. Vertical wall components will be modular walls. Double 90's channel section will be realigned and widened to approximately 140 feet.	Levees will be raised outside the existing ROW. The levee top and interior access roads constructed to 18-feet wide. Construction outside ROW will allow flatter slopes and less vertical wall components. Railroad crossing will be widened to approximately 135 feet.	Levees will be raised outside the existing ROW. The levee top and interior access roads constructed to 18-feet wide. Construction outside ROW will allow flatter slopes and less vertical wall components. Double 90's channel section will be realigned and widened to approximately 140 feet.	One levee will be replaced by vertical floodwall located 5-feet inside ROW to allow for an exterior planting strip. An 18-foot lower access road will be constructed adjacent to floodwall. Remaining levee will be raised and reconstructed within the ROW with 2:1 slopes. An 18-foot wide bench at the levee toe will be utilized as a vegetated strip.	600-foot wide floodplain with low levees to provide freeboard. Low flow channel allowed to meander within flood plain
Flood Protection *Capability to provide 1 percent (100-year) level of protection*	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection.	Provides 100-year level of protection.
Maintenance Access *Capability to provide access for safe and efficient maintenance*	Good. Upper levee and lower access roads provided to District standards on both sides of levee	Good. Upper levee and lower access roads provided to District standards on both sides of levee	Good. Upper levee and lower access roads provided to District standards on both sides of levee	Good. Upper levee and lower access roads provided to District standards on both sides of levee	Fair. Lower access road provided along base of floodwall and top of proposed levee.	Poor. No proposed access road except off top of levees. Wide flood plain will likely be inaccessible to maintenance equipment
Erosion *Potential effects on erosion of channel and existing levees*	Positive. New slope construction will reduce erosion	Positive. New slope construction will reduce erosion	Positive. New slope construction will reduce erosion	Positive. New slope construction will reduce erosion	Positive. New slope construction will reduce erosion	Positive. Wide flood plain will reduce flow velocities. New slope construction will reduce erosion
Sedimentation *Potential effects on deposition or generation of sediment*	Less than significant. No anticipated change from existing conditions.	Less than significant. Local sedimentation in vicinity of double 90's should reduce	Less than significant. No anticipated change from existing conditions.	Less than significant. Local sedimentation in vicinity of double 90's should reduce	Less than significant. Local sedimentation in vicinity of double 90's should reduce	Sedimentation may increase with wide flood plain and reduced velocities
Local Drainage *Potential effects on local surface and storm drainage systems*	Less than significant change in local drainage	Less than significant change in local drainage	Less than significant change in local drainage	Less than significant change in local drainage	Less than significant change in local drainage	Less than significant change in local drainage
Water Quality *Potential effects on water turbidity, temperature and/or pollution*	Existing conditions would remain	Existing conditions would remain	Existing conditions would remain	Existing conditions would remain	Existing conditions would remain	May be slight improvement due to wide flood plain allowing lower velocities and filtration o flows
Riparian Vegetation *Potential effects on riparian vegetation in channel*	Existing conditions would remain or be slightly reduced due to vertical wall components	Existing conditions would remain or be slightly reduced due to vertical wall components	Existing conditions would remain or be slightly reduced due to vertical wall components	Existing conditions would remain or be slightly reduced due to vertical wall components	Slight improvement with planting strip at base of levee. This will be countered somewhat by construction of flood wall	Significant improvement with vegetation opportunities in wid flood plain
Wetland *Potential effects on wetlands*	Existing conditions to remain	Existing conditions to remain	Existing conditions to remain	Existing conditions to remain	Existing conditions to remain	Significant improvement with wider flood plain
Wildlife Habitat *Potential effects on wildlife habitat*	Existing conditions to remain	Existing conditions to remain	Existing conditions to remain	Existing conditions to remain	Existing conditions to remain with potential for slight improvement with vegetated strip adjacent to levee	Significant improvement with wider flood plain
Fisheries *Potential effects on fish habitat*	Existing conditions to remain	Existing conditions to remain	Existing conditions to remain	Existing conditions to remain	Existing conditions to remain	Existing conditions may have slight improvement with shading effects of waterway due to improved riparian habitat
Aesthetics *Visual quality as viewed from within project boundaries and from adjacent viewshed*	Potentially negative. Taller levees and steeper slopes with vertical wall components could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration	Potentially negative. Taller levees and steeper slopes with vertical wall components could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration	Potentially negative. Taller levees and steeper slopes with vertical wall components could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration	Potentially negative. Taller levees and steeper slopes with vertical wall components could deteriorate appearance from adjacent residences and along channel. Some potential for mitigation by landscaping and creek bed restoration	Potentially negative. Levee height increased but slopes kept at 2:1 Floodwall will have negative visual impacts. Some potential for mitigation by landscaping outside floodwall and in internal vegetated strip and creek bed restoration.	Significant improvement due t wider floodplain and increased riparian habitat
Recreation *Capability of providing public access to trails*	Positive. Trails would be integrated with and access provided along levee section	Positive. Trails would be integrated with and access provided along levee section	Positive. Trails would be integrated with and access provided along levee section	Positive. Trails would be integrated with and access provided along levee section	Positive. Trails would be integrated with and access provided along levee section	Positive. Trails would be integrated with and access provided along levee section
Real Estate Acquisition *Extent, difficulty, and cost of acquiring additional right-of-way*	Limited. Additional ROW will be required for widened railroad section. Land required is probably publicly-owned.	Limited. Additional ROW will be required for the realigned channel in vicinity of railroad. Land required is probably publicly-owned.	Some private and public ROW will be required for widened levee footprint encroachment. Additional ROW will be required for widened railroad section. Land required is probably publicly-owned.	Some private and public ROW will be required for widened levee footprint encroachment Additional ROW will be required for the realigned channel in vicinity of railroad. Land required is probably publicly-owned.	Limited. Additional ROW will be required for the realigned channel in vicinity of railroad. Land required is probably publicly-owned.	Significant. Major impact to private property to acquire a 600-foot + wide right-of-way

SCREENING MATRIX

LOWER BERRYESSA CREEK PROJECT
BERRYESSA CREEK REACH

	Objective Weight Rank	Factor	1 - Raised Levees ≤ ROW	2 - Raised Levees ≤ ROW w/ Riparian Strip	3 - Levee/Wall System w/ Riparian Strip	4 - Levee/Wall System w/ two Riparian Strips
Objective 1: Flood Protection						
1.1 Safety		30	3.00	3.00	3.00	3.00
1.2 Economic Protection		30	3.00	3.00	3.00	3.00
1.3 Durability		10	3.00	3.00	3.00	3.00
1.4 Resiliency		10	3.00	3.00	3.00	3.00
1.5 Local Drainage		10	2.00	2.00	3.00	1.00
1.6 Time to implementation		10	3.00	3.00	2.00	2.00
Objective Score:	**10**		**2.90**	**2.90**	**2.90**	**2.70**
Objective 2: Ecological Functions						
2.1 Meets Local Habitat Goals		25	?	?	?	?
2.2 Quality of Habitat		25	1.00	2.00	2.00	3.00
2.3 Sustainablity of Habitat		25	1.00	2.00	2.00	3.00
2.4 Connectivity of Habitat		25	2.00	2.00	2.00	3.00
Objective Score:	**6**		**1.33**	**2.00**	**2.00**	**3.00**
Objective 3: Physical Stream Functions						
3.1 Floodplain		35	0.00	0.00	1.00	1.00
3.2 Active Channel		30	0.00	0.00	1.00	1.00
3.3 Stable Side Slopes		20	2.00	2.00	2.00	2.00
3.4 Upstream/Downstream Transitions		15	4.00	4.00	4.00	4.00
Objective Score:	**10**		**1.00**	**1.00**	**1.65**	**1.65**
Objective 4: Minimize Maintenance Requirements						
4.1 Structural Features		25	2.00	2.00	2.00	2.00
4.2 Natural Processes		25	1.00	1.00	1.00	1.00
4.3 Urban Flows		25	2.00	2.00	2.00	2.00
4.4 Access		25	3.00	2.00	1.00	1.00
Objective Score:	**10**		**2.00**	**1.75**	**1.50**	**1.50**
Objective 5: Intergrate within the Watershed						
5.1 Meets Local Watershed Goals		100	?	?	?	?
Objective Score:	**(5)**					
Objective 6: Proterct the quality and availability of water						
6.1 Water Availability		30	3	3	3	3
6.2 Instream Water Quality		40	2	3	3	4
6.3 Offstream Water Management		20	1	1	1	2
6.4 Flow Regime		10	3	3	3	3
Objective Score:	**6**		**2.20**	**2.60**	**2.60**	**3.20**
Objective 7: Local Agency Cooperation						
7.1 Mutual Local Goals		50	?	?	?	?
7.2 Supports General Plan		50	5	5	5	5
Objective Score:	**10**		**5.00**	**5.00**	**5.00**	**5.00**
Objective 8: Community Benefits						
8.1 Community Safety		15	?	?	?	?
8.2 Recreation		20	4.00	2.00	3.00	2.00
8.3 Aesthetics		15	2.00	3.00	2.00	3.00
8.4 Social & Cultural Benefits		5	2.00	2.00	2.00	2.00
8.5 Local Economic Effects		10	4.00	4.00	4.00	4.00
8.6 Green Construction & Operation		10	2.00	3.00	2.00	2.00
8.7 Open Space		10	3.00	3.00	3.00	3.00
8.8 Community Input		15	?	?	?	?
Objective Score:	**7**		**3.00**	**2.79**	**2.71**	**2.64**
Objective 9: Minimize life-cycle costs						
9.1 Capital Cost			3	2	3	1
9.2 Maintenance Cost			3	3	3	3
9.3 Grant or Cost-sharing Opportunities			?	?	?	?
Objective Score:	**7**		**3**	**2**	**3**	**2**
OVERALL RANKING	**61**		**2.82**	**2.75**	**2.92**	**2.92**

LOWER BERRYESSA CREEK PROJECT
TULARCITOS CREEK REACH

	Objective Weight Rank	Factor	1 - Pump Station	2 - Raise Banks ≥ ROW	3 - Flood Wall	4 - S P Flood Wall 1-Side
Objective 1: Flood Protection						
1.1 Safety		30	2	2	2	2
1.2 Economic Protection		30	3	3	2	3
1.3 Durability		10	2	3	3	2
1.4 Resiliency		10	3	3	3	3
1.5 Local Drainage		10	4	1	1	1
1.6 Time to implementation		10	4	3	5	2
Objective Score:	**10**		**2.80**	**2.50**	**2.40**	**2.30**
Objective 2: Ecological Functions						
2.1 Meets Local Habitat Goals		25	?	?	?	?
2.2 Quality of Habitat		25	2	2	2	4
2.3 Sustainablity of Habitat		25	3	3	3	3
2.4 Connectivity of Habitat		25	2	2	2	2
Objective Score:	**6**		**2.33**	**2.33**	**2.33**	**3.00**
Objective 3: Physical Stream Functions						
3.1 Floodplain		35	0	0	0	1
3.2 Active Channel		30	0	0	0	1
3.3 Stable Side Slopes		20	2	2	2	2
3.4 Upstream/Downstream Transitions		15	1	4	4	4
Objective Score:	**10**		**0.55**	**1.00**	**1.00**	**1.65**
Objective 4: Minimize Maintenance Requirements						
4.1 Structural Features		25	0	1	1	1
4.2 Natural Processes		25	2	2	2	2
4.3 Urban Flows		25	1	2	2	2
4.4 Access		25	0	1	0	1
Objective Score:	**10**		**0.75**	**1.50**	**1.25**	**1.50**
Objective 5: Intergrate within the Watershed						
5.1 Meets Local Watershed Goals		100	?	?	?	?
Objective Score:	**(5)**					
Objective 6: Proterct the quality and availability of water						
6.1 Water Availability		30	3	3	3	3
6.2 Instream Water Quality		40	3	3	3	4
6.3 Offstream Water Management		20	1	1	1	2
6.4 Flow Regime		10	3	4	4	4
Objective Score:	**6**		**2.60**	**2.70**	**2.70**	**3.30**
Objective 7: Local Agency Cooperation						
7.1 Mutual Local Goals		50	?	?	?	?
7.2 Supports General Plan		50	5	5	5	5
Objective Score:	**10**		**5.00**	**5.00**	**5.00**	**5.00**
Objective 8: Community Benefits						
8.1 Community Safety		15	?	?	?	?
8.2 Recreation		20	3	2	2	2
8.3 Aesthetics		15	3	2	1	3
8.4 Social & Cultural Benefits		5	3	3	3	3
8.5 Local Economic Effects		10	4	4	4	4
8.6 Green Construction & Operation		10	2	3	4	2
8.7 Open Space		10	3	3	3	3
8.8 Community Input		15	?	?	?	?
Objective Score:	**7**		**3.00**	**2.64**	**2.57**	**2.71**
Objective 9: Minimize life-cycle costs						
9.1 Capital Cost			3	4	5	1
9.2 Maintenance Cost			2	3	3	3
9.3 Grant or Cost-sharing Opportunities			?	?	?	?
Objective Score:	**7**		**2**	**4**	**4**	**2**
OVERALL RANKING	**61**		**2.55**	**2.90**	**2.83**	**2.87**

LOWER BERRYESSA CREEK PROJECT
LOWER CALERA CREEK REACH

	Objective Weight Rank	Factor	1 - Pump Station	2 - Raise Banks ≤ ROW	3 - Flood Wall	4 - S P Flood Wall 1-Side
Objective 1: Flood Protection						
1.1 Safety		30	2	3	2	2
1.2 Economic Protection		30	3	3	2	3
1.3 Durability		10	2	3	3	2
1.4 Resiliency		10	3	3	3	3
1.5 Local Drainage		10	3	2	2	2
1.6 Time to implementation		10	4	3	5	2
Objective Score:	**10**		**2.70**	**2.90**	**2.50**	**2.40**
Objective 2: Ecological Functions						
2.1 Meets Local Habitat Goals		25	?	?	?	?
2.2 Quality of Habitat		25	2	2	2	4
2.3 Sustainablity of Habitat		25	3	3	3	3
2.4 Connectivity of Habitat		25	2	2	2	3
Objective Score:	**6**		**2.33**	**2.33**	**2.33**	**3.33**
Objective 3: Physical Stream Functions						
3.1 Floodplain		35	0	0	0	1
3.2 Active Channel		30	0	0	0	1
3.3 Stable Side Slopes		20	2	2	2	2
3.4 Upstream/Downstream Transitions		15	2	2	2	2
Objective Score:	**10**		**0.70**	**0.70**	**0.70**	**1.35**
Objective 4: Minimize Maintenance Requirements						
4.1 Structural Features		25	0	1	1	1
4.2 Natural Processes		25	2	2	2	2
4.3 Urban Flows		25	1	2	2	2
4.4 Access		25	0	3	0	2
Objective Score:	**10**		**0.75**	**2.00**	**1.25**	**1.75**
Objective 5: Intergrate within the Watershed						
5.1 Meets Local Watershed Goals		100	?	?	?	?
Objective Score:	**(5)**					
Objective 6: Proterct the quality and availability of water						
6.1 Water Availability		30	3	3	3	3
6.2 Instream Water Quality		40	3	3	3	4
6.3 Offstream Water Management		20	1	1	1	1
6.4 Flow Regime		10	3	4	4	4
Objective Score:	**6**		**2.60**	**2.70**	**2.70**	**3.10**
Objective 7: Local Agency Cooperation						
7.1 Mutual Local Goals		50	?	?	?	?
7.2 Supports General Plan		50	5	5	5	5
Objective Score:	**10**		**5.00**	**5.00**	**5.00**	**5.00**
Objective 8: Community Benefits						
8.1 Community Safety		15	?	?	?	?
8.2 Recreation		20	3	2	2	2
8.3 Aesthetics		15	2	2	1	3
8.4 Social & Cultural Benefits		5	3	3	3	3
8.5 Local Economic Effects		10	4	4	4	4
8.6 Green Construction & Operation		10	2	3	4	2
8.7 Open Space		10	3	3	3	3
8.8 Community Input		15	?	?	?	?
Objective Score:	**7**		**2.79**	**2.64**	**2.57**	**2.71**
Objective 9: Minimize life-cycle costs						
9.1 Capital Cost			1	4	5	2
9.2 Maintenance Cost			2	3	3	3
9.3 Grant or Cost-sharing Opportunities			?	?	?	?
Objective Score:	**7**		**1**	**4**	**4**	**3**
OVERALL RANKING	**61**		**2.42**	**3.00**	**2.80**	**3.01**

LOWER BERRYESSA CREEK PROJECT
UPPER CALERA CREEK REACH 1

	Objective Weight Rank	Factor	1 - Flood Wall	2 - Raise Banks ≤ ROW	3 - Levee/Sheet Pile Wall	4 - Gravity By Pass
Objective 1: Flood Protection						
1.1 Safety		30	2	2	2	2
1.2 Economic Protection		30	2	3	3	2
1.3 Durability		10	3	3	2	2
1.4 Resiliency		10	3	3	3	3
1.5 Local Drainage		10	2	2	2	4
1.6 Time to implementation		10	5	3	2	4
Objective Score:	**10**		**2.50**	**2.60**	**2.40**	**2.50**
Objective 2: Ecological Functions						
2.1 Meets Local Habitat Goals		25	?	?	?	?
2.2 Quality of Habitat		25	2	2	3	2
2.3 Sustainablity of Habitat		25	3	3	3	5
2.4 Connectivity of Habitat		25	2	3	3	3
Objective Score:	**6**		**2.33**	**2.67**	**3.00**	**3.33**
Objective 3: Physical Stream Functions						
3.1 Floodplain		35	1	1	2	1
3.2 Active Channel		30	1	1	2	1
3.3 Stable Side Slopes		20	2	3	2	2
3.4 Upstream/Downstream Transitions		15	2	2	2	2
Objective Score:	**10**		**1.35**	**1.55**	**2.00**	**1.35**
Objective 4: Minimize Maintenance Requirements						
4.1 Structural Features		25	1	1	1	0
4.2 Natural Processes		25	2	2	2	3
4.3 Urban Flows		25	2	2	2	1
4.4 Access		25	1	3	2	1
Objective Score:	**10**		**1.50**	**2.00**	**1.75**	**1.25**
Objective 5: Intergrate within the Watershed						
5.1 Meets Local Watershed Goals		100	?	?	?	?
Objective Score:	**(5)**					
Objective 6: Proterct the quality and availability of water						
6.1 Water Availability		30	3	3	3	2
6.2 Instream Water Quality		40	3	3	4	3
6.3 Offstream Water Management		20	1	1	1	1
6.4 Flow Regime		10	4	4	4	3
Objective Score:	**6**		**2.70**	**2.70**	**3.10**	**2.30**
Objective 7: Local Agency Cooperation						
7.1 Mutual Local Goals		50	?	?	?	?
7.2 Supports General Plan		50	5	5	5	5
Objective Score:	**10**		**5.00**	**5.00**	**5.00**	**5.00**
Objective 8: Community Benefits						
8.1 Community Safety		15	?	?	?	?
8.2 Recreation		20	2	2	2	2
8.3 Aesthetics		15	1	2	3	2
8.4 Social & Cultural Benefits		5	2	2	2	2
8.5 Local Economic Effects		10	4	4	4	4
8.6 Green Construction & Operation		10	4	3	2	2
8.7 Open Space		10	3	3	3	3
8.8 Community Input		15	?	?	?	?
Objective Score:	**7**		**2.50**	**2.57**	**2.64**	**2.43**
Objective 9: Minimize life-cycle costs						
9.1 Capital Cost			5	3	1	3
9.2 Maintenance Cost			3	3	3	2
9.3 Grant or Cost-sharing Opportunities			?	?	?	?
Objective Score:	**7**		**4**	**3**	**2**	**3**
OVERALL RANKING	**61**		**2.94**	**3.00**	**2.96**	**2.83**

LOWER BERRYESSA CREEK PROJECT
UPPER CALERA CREEK REACH 2

	Objective Weight Rank	Factor	1 -Flood Wall	2 - Detention Basin	3 - Pump Station	4 - Gravity By Pass
Objective 1: Flood Protection						
1.1 Safety		30	2	2	2	2
1.2 Economic Protection		30	2	3	3	3
1.3 Durability		10	3	3	2	2
1.4 Resiliency		10	3	3	3	3
1.5 Local Drainage		10	2	4	4	4
1.6 Time to implementation		10	5	1	3	4
Objective Score:	**10**		**2.50**	**2.60**	**2.70**	**2.80**
Objective 2: Ecological Functions						
2.1 Meets Local Habitat Goals		25	?	?	?	?
2.2 Quality of Habitat		25	1	2	2	1
2.3 Sustainablity of Habitat		25	2	5	5	5
2.4 Connectivity of Habitat		25	2	3	3	2
Objective Score:	**6**		**1.67**	**3.33**	**3.33**	**2.67**
Objective 3: Physical Stream Functions						
3.1 Floodplain		35	0	0	0	0
3.2 Active Channel		30	0	0	0	0
3.3 Stable Side Slopes		20	0	0	0	0
3.4 Upstream/Downstream Transitions		15	3	3	3	3
Objective Score:	**10**		**0.45**	**0.45**	**0.45**	**0.45**
Objective 4: Minimize Maintenance Requirements						
4.1 Structural Features		25	1	1	0	0
4.2 Natural Processes		25	2	3	3	3
4.3 Urban Flows		25	2	4	1	1
4.4 Access		25	0	0	1	1
Objective Score:	**10**		**1.25**	**2.00**	**1.25**	**1.25**
Objective 5: Intergrate within the Watershed						
5.1 Meets Local Watershed Goals		100	?	?	?	?
Objective Score:	**(5)**					
Objective 6: Proterct the quality and availability of water						
6.1 Water Availability		30	3	3	2	2
6.2 Instream Water Quality		40	3	4	3	3
6.3 Offstream Water Management		20	1	3	1	1
6.4 Flow Regime		10	4	5	3	3
Objective Score:	**6**		**2.70**	**3.60**	**2.30**	**2.30**
Objective 7: Local Agency Cooperation						
7.1 Mutual Local Goals		50	?	?	?	?
7.2 Supports General Plan		50	5	5	5	5
Objective Score:	**10**		**5.00**	**5.00**	**5.00**	**5.00**
Objective 8: Community Benefits						
8.1 Community Safety		15	?	?	?	?
8.2 Recreation		20	1	1	1	1
8.3 Aesthetics		15	0	3	2	1
8.4 Social & Cultural Benefits		5	1	1	1	1
8.5 Local Economic Effects		10	4	4	3	4
8.6 Green Construction & Operation		10	4	3	1	2
8.7 Open Space		10	3	2	3	3
8.8 Community Input		15	?	?	?	?
Objective Score:	**7**		**1.93**	**2.29**	**1.79**	**1.86**
Objective 9: Minimize life-cycle costs						
9.1 Capital Cost			5	2	1	3
9.2 Maintenance Cost			2	2	1	1
9.3 Grant or Cost-sharing Opportunities			?	?	?	?
Objective Score:	**7**		**3**	**2**	**1**	**2**
OVERALL RANKING	**61**		**2.50**	**2.82**	**2.41**	**2.49**

APPENDIX D
CONCEPT DRAWINGS

SEPARATE PDF

APPENDIX E - OPINION OF PROBABLE CONSTRUCTION COSTS

Lower Berryessa Creek Element

Item	Unit Cost	Unit	Quantity	Amount
DIVISION 1- GENERAL REQUIREMENTS				
Estimated as 10% of total construction, applied to subtotal at end				
DIVISION 2- EXISTING CONDITIONS				
Demolition				
Remove bridge at Calera Creek, store	$7,120.00	CREW DAY	5	$ 35,600
Demolish bridge abutments @ Calera Creek, haul & dispose debris	$180.00	CY	60	$ 10,800
Remove pedestrian bridge, store	$7,120.00	CREW DAY	5	$ 35,600
Demolish pedestrian bridge abutments, ramps. Haul & dispose debris	$180.00	CY	60	$ 10,800
DIVISION 3- CONCRETE				
Cast-In-Place Concrete				
Main flood wall- foundation	$312.00	CY	11,000	$ 3,432,000
Main flood wall- wall	$560.00	CY	5,300	$ 2,968,000
Abutments for vehicular bridge at Calera Creek	$560.00	CY	130	$ 72,800
Abutments for pedestrian bridge	$560.00	CY	105	$ 58,800
Retaining walls @ RR crossing	$560.00	CY	482	$ 269,920
Retaining walls @ N. Milpitas Blvd Bridge	$470.00	CY	106	$ 49,820
Retaining walls @ Town Center access ramp	$470.00	CY	107	$ 50,290
Flood walls @ Tularcitos Creek	$470.00	CY	140	$ 65,800
DIVISION 31- EARTHWORK				
Clear & Grub				
Selective Clearing				
Existing levees	$1,300.00	AC	3	$ 4,472
Toes of existing levees (to extent of excvations)	$1,300.00	AC	6	$ 7,163
Access roads	$1,300.00	AC	4	$ 4,810
Topsoil Stripping & Stockpiling				
Existing levees	$1.34	SY	16,667	$ 22,334
Toes of existing levees (to extent of excvations)	$1.34	SY	26,667	$ 35,734
Access roads	$1.34	SY	17,889	$ 23,971
Shoring				
Wood sheeting for flood wall excavation	$9.75	SF	8,883	$ 86,609
Excavation and Fill				
Excavating				
for levee replaced by floodwall (incl excavation to prop line for flood wall)				
bulk bank measure	$1.84	BCY	174,848	$ 321,721
for levee, reconstruted ((benched)				
bulk bank measure	$1.84	BCY	17,250	$ 31,740
final benching,	$1.69	BCY	23,805	$ 40,242
Dewatering- toe of access road	$200.00	DAYS	120	$ 24,000
Hauling- net spoils from levee excavation,	$9.54	LCY	233,698	$ 2,229,479
Disposal- assume no disposal charge	$0.00	LCY	233,698	$ -

Lower Berryessa Creek Element

Item	Unit Cost	Unit	Quantity	Amount
Embankment fill				
Reconstruted levee, compacted	$21.00	CY	110,207	$ 2,314,343
Reconstruted levee- borrow (top 1 foot), compacted	$47.00	CY	23,460	$ 1,102,620
Bench for vegetation strip- native, compacted	$2.73	ECY	7,359	$ 20,090
Soil-Cement (in place cost)				
Flood wall and lower maintance road, incl turnouts	$50.00	CY	43,000	$ 2,150,000
Guide vane, Sta 0+00	$50.00	CY	1,037	$ 51,850
Apron at RR crossing culverts	$50.00	CY	625	$ 31,250
Controlled Low Strength Material (CLSM), flowable fill				
Between outside face of flood wall and ROW	$112.00	CY	8,000	$ 896,000
Grading				
Finish Grading				
Reconstructed levee slopes & top	$22.00	MSF	551	$ 12,122
Bench for vegetation	$0.70	SY	8,700	$ 6,090
Existing channel (dress up)	$0.70	SY	66,000	$ 46,200
Screening slope, outside flood wall Sta 37+00	$1.71	SY	1,100	$ 1,881
Erosion Control				
Erosion control mat at reconstructed levee	$8.80	SY	61,300	$ 539,440
Erosion control mat at bench for vegetation strip	$8.80	SY	8,700	$ 76,560
Riprap				
at Sta 29+00	$88.00	LCY	100	$ 8,800
DIVISION 32- EXTERIOR IMPROVEMENTS				
Base Courses				
Aggregate Base Courses				
Maintenance road at top of levee, 12" deep	$23.40	SY	17,900	$ 418,860
Other access roads, 12" deep	$23.40	SY	21,200	$ 496,080
Flexible Paving				
Maintenance road at top of levee	$18.62	SY	18,000	$ 335,160
Other access roads, pedestrian bridge access	$18.62	SY	21,200	$ 394,744
Fences and Gate				
Allowance		ALLOW	1	$ 30,000
Fabricated Bridges				
Replace existing pedestrian bridge on new abutments	$11.25	SF	1,440	$ 16,200
Replace vehicular bridge @ Calera Creek on new abutments	$11.25	SF	1,300	$ 14,625
Landscape Grading				
Topsoil Placement and Grading				
Reconstructed levee slopes	$5.70	ECY	20,500	$ 116,850
Vegetation strip	$5.70	ECY	7,400	$ 42,180

Lower Berryessa Creek Element

Item	Unit Cost	Unit	Quantity	Amount
Seeding				
Hyro seeding w/mulch				
Reconstructed levee slopes	$0.62	SY	61,300	$ 38,006
Vegetation strip	$0.62	SY	8,700	$ 5,394
Shrubs and Trees				
at Vegetation strip	$7.00	SY	61,300	$ 429,100
DIVISION 33- UTILITIES				
Water Distribution				
Relocate water lines, allowance		ALLOW	1	$ 50,000
Liquid Fuel Distribution				
Relocate oil distribution pipe, allowance		ALLOW	1	$ 100,000
Electrical and Communication Structures				
Relocate underground ducts and manholes, allowance		ALLOW	1	$ 50,000
Subtotal, Construction				$ 19,686,950
General Conditions, estimated at 10% of subtotal	10%		19,686,950	$ 1,968,695
Subtotal, Construction plus General Conditions				$ 21,655,645
Sales tax on materials, assumed at 40% of total cost	9.25%		8,662,258	$ 801,259
Total Construction Contract Cost				$ 22,456,904
Contingency	10%		22,456,904	$ 2,245,690
Total Construction Budget (Rounded)				**$ 24,700,000**
Design and Construction Engineering	10%		24,700,000	**$ 2,470,000**
Total Project Budget (Rounded)				**$ 27,200,000**

Lower Calera Creek Element

Item	Unit Cost	Unit	Quantity	Amount
DIVISION 1- GENERAL REQUIREMENTS				
Estimated as 10% of total construction, applied to subtotal at end				
DIVISION 2- EXISTING CONDITIONS				
Demolition				
Demolish access ramp and channel walls @ Milpitas Blvd., haul & dispose debris	$15.80	SY	380	$ 6,004
Haul debris and dispose	$18.00	CY	14	$ 252
Demolish flood walls and headwalls @ RR crossing	$420.00	LF	40	$ 16,800
DIVISION 3- CONCRETE				
Cast-In-Place Concrete				
Main flood wall- foundation	$310.00	CY	1,471	$ 456,010
Main flood wall- wall	$470.00	CY	1,256	$ 590,320
Maintenance access ramp downstream of Milpitas Blvd, base slab	$420.00	CY	377	$ 158,340
Maintenance access ramp downstream of Milpitas Blvd, walls	$470.00	CY	303	$ 142,410
Flood wall and head walls @ Milpitas Blvd Bridge	$585.00	CY	180	$ 105,300
Flood wall and head walls @Arizona Ave. Bridge	$585.00	CY	230	$ 134,550
Abutments for slab bridge @ RR crossing	$560.00	CY	150	$ 84,000
Slab for bridge @ RR crossing	$715.00	CY	30	$ 21,450
Headwall for bridge @ RR crossing	$585.00	CY	6	$ 3,510
DIVISION 31- EARTHWORK				
Clear & Grub				
Selective Clearing				
Existing levees	$1,600.00	ACRE	1.2	$ 1,920
Toes of existing levees (to extent of excvations)	$1,300.00	ACRE	0.7	$ 910
Access roads	$1,300.00	ACRE	0.7	$ 910
Topsoil Stripping & Stockpiling				
Existing levees	$1.34	SY	5,600	$ 7,504
Toes of existing levees (to extent of excvations)	$1.34	SY	3,000	$ 4,020
Access roads	$1.34	SY	3,400	$ 4,556
Excavation and Fill				
Excavating				
for levee excavation to create low bench				
dozer or F.E. loader	$1.84	BCY	19,780	$ 36,395
for new floodwalls				
wheel mounted backhoe	$4.37	BCY	1,691	$ 7,390
Dewatering- toe of bench	$200.00	DAY	20	$ 4,000
Hauling- net spoils from levee, floodw all foundation excavation	$9.54	LCY	21,471	$ 204,833
Disposal- assume no disposal charge	$0.00	LCY	-	$ -
Embankment fill				
Fill at floodwalls	$21.00	CY	2,070	$ 43,470
Grading				
Finish Grading				
Reconstructed levee slopes & top	$22.00	MSF	79	$ 1,728
Bench for vegetation	$0.70	SY	6,400	$ 4,480
Existing channel (dress up)	$0.70	SY	3,000	$ 2,100
Outside flood wall	$1.71	SY	3,000	$ 5,130
Erosion Control				
Erosion control mat at reconstructed levee	$8.80	SY	5,400	$ 47,520
Erosion control mat at bench for vegetation strip	$8.80	SY	6,400	$ 56,320

Lower Calera Creek Element

Item	Unit Cost	Unit	Quantity	Amount
DIVISION 32- EXTERIOR IMPROVEMENTS				
Base Courses				
Aggregate Base Courses				
Maintenance road at top of levee	$24.00	SY	4,700	$ 112,800
Maintenance path adjacent to flood wall	$24.00	SY	250	$ 6,000
Fences and Gate				
Allowance		ALLOW	1	$ 15,000
Landscape Grading				
Topsoil Placement and Grading				
Reconstructed levee slopes	$5.70	ECY	1,800	$ 10,260
Vegetation strip	$5.70	ECY	2,200	$ 12,540
Seeding				
Hyro seeding w/mulch				
Reconstructed levee slopes	$0.62	SY	5,400	$ 3,348
Vegetation strip	$0.62	SY	6,400	$ 3,968
Shrubs and Trees				
at Vegetation strip	$7.00	SY	6,400	$ 44,800
Subtotal, Construction				$ 2,360,848
General Conditions, estimated at 10% of subtotal	10%		2,360,848	$ 236,085
Subtotal, Construction plus General Conditions				$ 2,596,933
Sales tax on materials, assumed at 40% of total cost	9.25%		1,038,773	$ 96,087
Total Construction Contract Cost				$ 2,693,020
Contingency	10%		2,693,020	$ 269,302
Total Construction Budget (Rounded)				**$ 3,000,000**
Design and Construction Engineering	10%		3,000,000	**$ 300,000**
Total Project Budget (Rounded)				**$ 3,300,000**

Tularcitos Creek Element

Item	Unit Cost	Unit	Quantity	Amount
DIVISION 1- GENERAL REQUIREMENTS				
Estimated as 10% of total construction, applied to subtotal at end				
DIVISION 2- EXISTING CONDITIONS				
Demolition				
Remove pedestrian bridges, store	$5,000.00	CREW DAY	3	$ 15,000
Demolish pedestrian bridge abutments. Haul & dispose debris	$180.00	CY	22	$ 3,960
DIVISION 3- CONCRETE				
Cast-In-Place Concrete				
Pump Station				
Base slabs	$420.00	CY	1,054	$ 442,680
Walls	$560.00	CY	1,020	$ 571,200
Floor slab (over wet well)	$950.00	CY	467	$ 443,650
Roof fill on metal deck	$2.77	SF	7,000	$ 19,390
Outlet Channel				
Base, sides	$630.00	CY	141	$ 88,830
Walls	$630.00	CY	68	$ 42,840
Top	$895.00	CY	119	$ 106,505
Flood Walls				
Foundations	$310.00	CY	750	$ 232,500
Walls	$470.00	CY	460	$ 216,200
Pedestrian bridge abutments	$560.00	CY	20	$ 11,200
Headwalls @ Tramway Dr bridge	$560.00	CY	39	$ 21,840
Headwalls @ N. Hillview bridge	$560.00	CY	31	$ 17,360
DIVISION 4- MASONRY				
Concrete Unit Masonry				
Pump station building walls, 12" thick split face	$20.00	SF	12,200	$ 244,000
Pump station wall reinf	$2.00	LB	24,400	$ 48,800
DIVISION 5- METALS				
Structural Steel Framing				
Pump Station				
Roof, longspan joists	$44.00	LF	1,300	$ 57,200
Roof decking	$4.00	SF	7,300	$ 29,200
Grating, inlet channel (including misc framing)	$53.66	SF	1,530	$ 82,107
Metal Railings and Fabrications				
Miscellenous metal (ladders, railings, etc.), allownance		ALLOW	1	$ 5,000
DIVISION 7- THERMAL AND MOISTURE PROTECTION				
Pump Station, Roof				
Rigid insulation	$3.00	SF	7,000	$ 21,000
Built-up roofing	$340.00	SQ	70	$ 23,800
Roof hatches	$3.00	EA	19,800	$ 59,400

Tularcitos Creek Element

Item	Unit Cost	Unit	Quantity	Amount
DIVISION 8- OPENINGS				
Pump Station				
Door frames, man-doors	$212.00	EA	3	$ 636
Door frame, overhead door	$2,200.00	EA	1	$ 2,200
Hollow metal doors,insulated	$525.00	EA	3	$ 1,575
Overhead coiling door	$6,770.00	EA	1	$ 6,770
Door hardware, allowance		ALLOW	1	$ 2,400
DIVISION 9 - FINISHES				
Pump Station Restroom				
Door, floor, ceiling, finishes allowance		ALLOW		$ 3,500
Painting				
Pump Station				
Exterior walls, sealer, anti-graffiti coating (2 coats)	$1.00	SF	13,200	$ 13,200
Interior walls	$0.60	SF	12,204	$ 7,322
Floor: dustproofing, (2coats)	$1.00	SF	7,000	$ 7,000
Roof framing	$1.00	SF	7,000	$ 7,000
Sound Absorptive Panels				
Pump Station				
Walls, fiberglass 1" thick	$14.00	SF	11,200	$ 156,800
Ceiling, fiberglass 2-1/4" thick	$20.00	SF	7,000	$ 140,000
DIVISION 10 - SPECIALITIES				
Signage				
Pump station, allowance		ALLOW		$ 1,000
Toilet Accessories				
Pump station, allowance		ALLOW		$ 2,500
Lockers				
Pump station, allowance		ALLOW		$ 1,000
DIVISION 21 - FIRE SUPRESSION				
Wet-Pipe Sprinkler System				
Pump station				
6" sch 40 w/ clevis hangars & fittings	$143.66	LF	90	$ 12,929
4" sch 40 w/ clevis hangars & fittings	$84.78	LF	120	$ 10,174
2" sch 40 w/ clevis hangars & fittings	$38.47	LF	490	$ 18,848
sprinkler heads (10' x 10' spacing)	$48.85	EA	56	$ 2,735
misc. isolation valves and testing accessories	$10,000.00	LS	1	$ 10,000
DIVISION 22- PLUMBING				
Facility Water/Sewer Distribution				
Pump station domestic water and sanitary waste systems	$9.20	SF	6,300	$ 57,960
DIVISION 23- HVAC				
Heating/Ventilating				
Pump station	$11.90	SF	6,300	$ 74,970

Tularcitos Creek Element

Item	Unit Cost	Unit	Quantity	Amount
Facility Fuel Systems				
8,000 gal double-wall Convault w/ piping, accessories, & anchorages	$88,380.00	LS	1	$ 88,380
Day tank	$10,000.00	LS	1	$ 10,000
DIVISION 26- ELECTRICAL				
Building Power Distribtion and Lighting				
Pump station	$12.40	SF	6,300	$ 78,120
Control Systems				
PLC & HMI w/ radio telemetry	$70,000.00	LS	1	$ 70,000
DIVISION 28- ELECTRONIC SAFETY AND SECURITY				
Intrusion Detection				
Pump station , allowance		ALLOW		$ 3,000
Fire Detection and Alarm				
Pump station, allowance		ALLOW		$ 5,500
DIVISION 31- EARTHWORK				
Clear & Grub				
Selective Clearing				
Pump station site	$1,000.00	LS	1	$ 1,000
Top soil stripping	$1.34	CY	511	$ 685
Shoring				
Sheet piling for pump station excavation	$27.50	SF	17,400	$ 478,413
Excavation and Fill				
Excavating				
Pump station excvation, crawler mounted excavator	$1.84	CY	12,400	$ 22,857
Flood wall foundations, wheel mounted backhoe	$4.37	CY	863	$ 3,774
Prep subgrade for maintenance roads, front end loader, wheel mounted	$3.11	CY	4,092	$ 12,735
Dewatering- Pump station excavation				
first-month well points 5' on center (incl pumps, piping, disposal)	$450.90	LF	200	$ 90,180
month 2 - well points 5' on center (incl pumps, piping, disposal)	$290.58	LF	200	$ 58,116
month 3 - well points 5' on center (incl pumps, piping, disposal)	$290.58	LF	200	$ 58,116
month 4 - well points 5' on center (incl pumps, piping, disposal)	$290.58	LF	200	$ 58,116
month 5 - well points 5' on center (incl pumps, piping, disposal)	$290.58	LF	200	$ 58,116
month 6 - well points 5' on center (incl pumps, piping, disposal)	$290.58	LF	200	$ 58,116
Hauling- net spoils from excavations				
Pump station	$9.54	CY	17,875	$ 170,528
Flood wall foundations	$9.54	CY	863	$ 8,233
Maintenance roads	$9.54	CY	5,090	$ 48,559
Disposal- assume no disposal charge				
Backfill, Structural				
Pump station	$3.87	CY	1,746	$ 6,761
Flood walls	$3.87	CY	2,077	$ 8,043
Maintenance Roads	$3.87	CY	484	$ 1,874
Compaction, Structural				
Pump station	$1.59	CY	1,746	$ 2,778
Flood walls	$1.59	CY	2,077	$ 3,305
Maintenance Roads	$1.59	CY	484	$ 770

Tularcitos Creek Element

Item	Unit Cost	Unit	Quantity	Amount
Grading				
Finish Grading				
Pump station site	$0.72	SY	442	$ 319
Maintenance roads	$0.72	SY	10,622	$ 7,663
DIVISION 32- EXTERIOR IMPROVEMENTS				
Base Courses				
Aggregate Base Courses				
Pump station site	$62.60	CY	957	$ 59,908
Maintenance roads	$62.60	CY	3,541	$ 221,667
Flexible Paving				
Pump station site	$18.62	SY	440	$ 8,193
Fences and Gate				
Pump station site	$37.42	LF	230	$ 8,607
double leaf gate	$1,625.78	EA	1	$ 1,626
Fabricated Bridges				
Replace existing pedestrian bridges on new abutments		ALLOW	1	$ 7,000
DIVISION 33- UTILITIES				
Water Distribution				
Pump Station				
Domestic water supply piping, incl trench & meter	$5,000.00	LS	1	$ 5,000
Fire protection water supply piping, incl trench	$10,000.00	LS	1	$ 10,000
Sanitary Utility Sewer				
Pump Station				
Sanitary sewer piping, incl trench	$10,000.00	LS	1	$ 10,000
Storm Utility Drainage Pumps				
Pump engines (1250 hp Cat 3512C w/ accessories)	$399,000.00	EA	3	$ 1,197,000
Pumps w/ right-angle gear drive (186,000 gpm @ 19.5 ft)	$1,464,035.00	EA	3	$ 4,392,105
Crane mobilization for pump installation	$9,650.00	LS	1	$ 9,650
Outlet piping and coupling	$10,000.00	EA	3	$ 30,000
48-inch flap gate w/ wall thimble	$15,000.00	EA	6	$ 90,000
DIVISION 41- MATERIAL PROCESSING AND HANDLING				
Cranes and Hoists				
Bridge crane, 3 ton	$60,000.00	EA	1	$ 60,000
Subtotal, Construction				$10,868,995
General Conditions, estimated at 10% of subtotal	10%		10,868,995	$ 1,086,899
Subtotal, Construction plus General Conditions				$ 11,955,894
Sales tax on materials, assumed at 40% of total cost	9.25%		4,782,358	$ 442,368
Total Construction Contract Cost				$ 12,398,263
Contingency	10%		12,398,263	$ 1,239,826
Total Construction Budget (Rounded)				**$ 13,600,000**
Design and Construction Engineering	10%		13,600,000	**$ 1,360,000**
Total Project Budget (Rounded)				**$ 15,000,000**

Lower Berryessa Creek Project
Opinion of Probable Design Construction Cost

Upper Calera Creek Element 1

Item	Unit Cost	Unit	Quantity	Amount
DIVISION 1- GENERAL REQUIREMENTS				
Estimated as 10% of total construction, applied to subtotal at end				
DIVISION 3- CONCRETE				
Cast-In-Place Concrete				
Main flood wall- foundation	$310.00	CY	549	$ 170,190
Main flood wall- wall	$470.00	CY	397	$ 186,590
Flood wall and head walls @ Escuela Parkway Culvert	$585.00	CY	102	$ 59,670
DIVISION 31- EARTHWORK				
Clear & Grub				
Selective Clearing				
Access roads	$1,300.00	ACRE	0.8	$ 1,040
Topsoil Stripping & Stockpiling				
Existing bank (north side downstream of Escuela)	$1.34	SY	2,000	$ 2,680
Access roads	$1.34	SY	4,000	$ 5,360
Excavation and Fill				
Excavating				
for new floodwalls				
wheel mounted backhoe	$4.37	BCY	631	$ 2,759
Hauling- net spoils from levee excavation,	$9.54	LCY	4,875	$ 46,508
Disposal- assume no disposal charge	$0.00	LCY	-	$ -
Embankment fill				
Fill at floodwalls	$21.00	CY	1,300	$ 27,300
Grading				
Finish Grading				$ -
Reconstructed levee access roads	$0.70	SY	4,000	$ 2,800
Outside flood wall	$1.71	SY	1,600	$ 2,736
DIVISION 32- EXTERIOR IMPROVEMENTS				
Base Courses				
Aggregate Base Courses				
Maintenance road at top of levee	$24.00	SY	4,000	$ 96,000
Fences and Gate				
Allowance		ALLOW	1	$ 5,000
Landscape Grading				
Topsoil Placement and Grading				
Outside flood wall	$5.70	ECY	270	$ 1,539
Seeding				
Hydro seeding w/mulch				
Outside flood wall	$0.62	SY	1,600	$ 992
DIVISION 33- UTILITIES				
Storm Drainage				
Local storm drainage outside floodwall				
Catch basins, pipe and flap gates	$10,000.00	EA	10	$ 100,000

Upper Calera Creek Element 1

Item	Unit Cost	Unit	Quantity	Amount
Subtotal, Construction				$ 711,163
General Conditions, estimated at 10% of subtotal	10%		711,163	$ 71,116
Subtotal, Construction plus General Conditions				$ 782,280
Sales tax on materials, assumed at 40% of total cost	9.25%		312,912	$ 28,944
Total Construction Contract Cost				$ 811,224
Contingency	10%		811,224	$ 81,122
Total Construction Budget (Rounded)				**$ 900,000**
Design and Construction Engineering	10%		900,000	**$ 90,000**
Total Project Budget (Rounded)				**$ 1,000,000**

Lower Berryessa Creek Project

Opinion of Probable Design & Construction Costs

Upper Calera Creek Element 2

Item	Unit Cost	Unit	Quantity	Amount
DIVISION 1- GENERAL REQUIREMENTS				
Estimated as 10% of total construction, applied to subtotal at end				
DIVISION 3- CONCRETE				
Cast-In-Place Concrete				
Main flood wall- foundation - upstream end of project	$310.00	CY	114	$ 35,340
Main flood wall- wall - upstream end of project	$470.00	CY	120	$ 56,400
Base for Concrete box channel	$420.00	CY	714	$ 299,880
Walls for Concrete box channel	$585.00	CY	714	$ 417,690
Abutments for pedestrian bridge	$560.00	CY	55	$ 30,800
Base for Concrete box inlet	$420.00	CY	35	$ 14,700
Walls for Concrete box inlet	$585.00	CY	15	$ 8,775
DIVISION 5 - METALS				
Steel grating for concrete box channel	$36.31	SF	6,000	$ 217,881
Steel sheet piling at park	$2,809.16	Ton	40	$ 112,366
DIVISION 31- EARTHWORK				
Clear & Grub				
Selective Clearing				
15' Draiange Easement	$2,000.00	LS	1	$ 2,000
Excavation and Fill				
Excavating				
for open concrete box channel excavation				
hydraulic crawler-mounted excavator	$1.91	CY	4,150	$ 7,939
for new floodwalls and channel reconstruction (Ped brridge, park,London Dr)				
wheel-mounted backhoe	$4.37	CY	1,300	$ 5,681
Maintenance roads	$3.11	CY	141	$ 439
Hauling- net spoils from excavation,				
Open concrete box channel	$9.54	CY	5,188	$ 49,494
Floodwall/Channel excavation	$9.54	CY	1,600	$ 15,264
Maintenance roads	$9.54	CY	176	$ 1,679
Disposal- assume no disposal charge	$0.00	CY	6,964	$ -
Backfill, Structural				
Fill at open concrete box channel	$21.00	CY	1,985	$ 41,683
Fill at floodwalls	$21.00	CY	113	$ 2,363
Compaction, Structural (cost included in Backfill cost)				
Grading				
Finish Grading				
Existing channel (dress up)	$2,000.00	LS	1	$ 2,000
Maintenance roads	$2,000.00	LS	1	$ 2,000
Erosion Control				
Erosion control mat at reconstructed channel	$8.80	SY	910	$ 8,008

Lower Berryessa Creek Project

Opinion of Probable Design & Construction Costs

Upper Calera Creek Element 2

Item	Unit Cost	Unit	Quantity	Amount
DIVISION 32- EXTERIOR IMPROVEMENTS				
Base Courses				
Aggregate Base Courses				
Maintenance road at top of levee				
Open Channel Box Channel	$62.60	CY	677	$ 42,359
Fences and Gate				
Fabricated Bridges				
New pedestrian bridge on new abutments	$103.95	SF	800	$ 83,160
Seeding				
Hyro seeding w/mulch				
Reconstructed levee slopes	$0.62	SY	910	$ 564
Subtotal, Construction				$1,467,564
General Conditions, estimated at 10% of subtotal	10%		1,467,564	$ 146,756
Subtotal, Construction plus General Conditions				$ 1,614,320
Sales tax on materials, assumed at 40% of total cost	9.25%		645,728	$ 59,730
Total Construction Contract Cost				$ 1,674,050
Contingency	10%		1,674,050	$ 167,405
Total Construction Budget (Rounded)				**$ 1,800,000**
Design and Construction Engineering	10%		1,800,000	**$ 180,000**
Total Project Budget (Rounded)				**$ 2,000,000**